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Royal and District Agricultural Societies' 50-Acre Crop Competitions, 1939.

I. THOMAS, Superintendent of Wheat Farming.

The 50-acre Crop Competitions were inaugurated in this State during 1921 with the object of improving the farming methods of the State by creating a spirit of healthy rivalry among farmers and by focussing attention upon the methods of the successful competitors. As can be readily understood, there is considerable variation in rainfall, soil, etc., in a wheat-belt so widely extended as it is in this State. For these reasons the wheat-belt has been sub-divided into eight zones, in such a manner that districts having similar interests and climatic conditions have been grouped together; in this way farmers may compete with each other more equitably. The accompanying map shows the eight zones referred to.

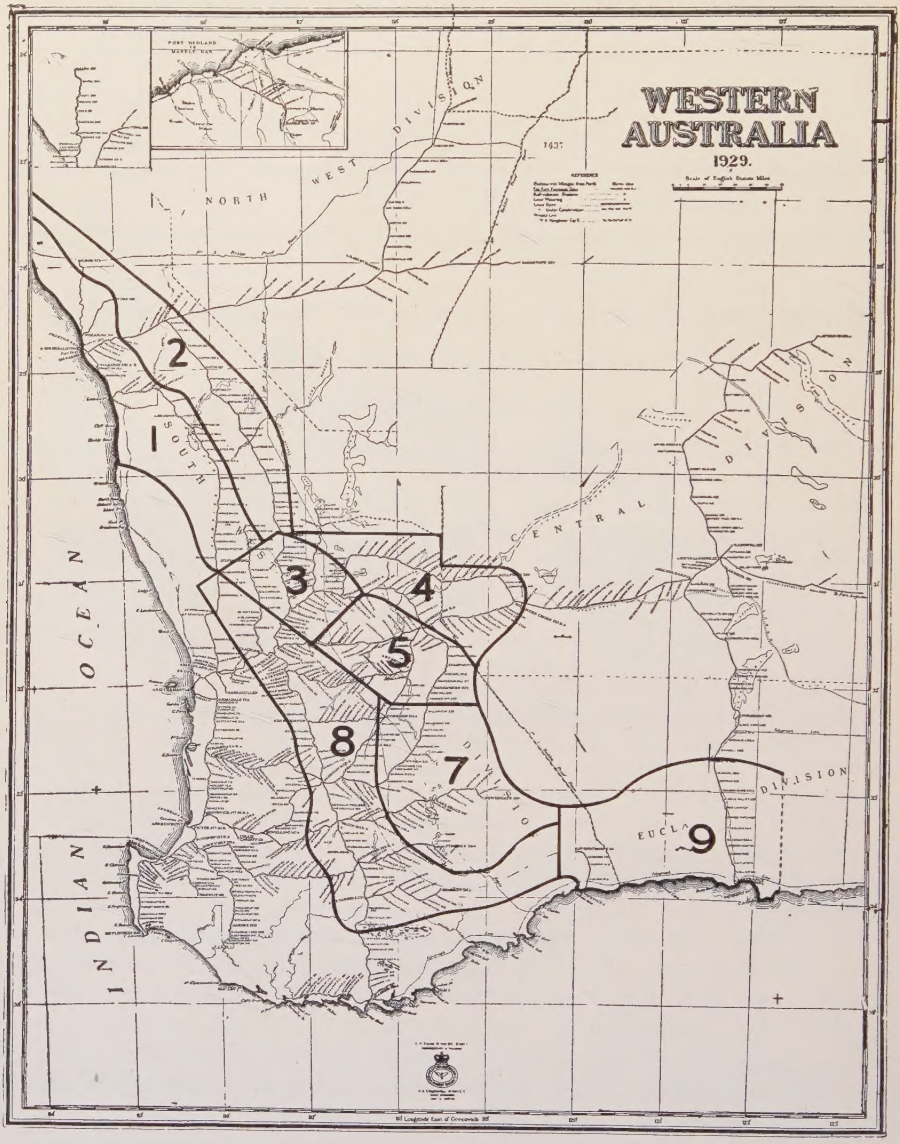
Entry for these competitions is made through the affiliated district Agricultural Societies; the first and second prize winners of these district competitions automatically become eligible to compete for the prizes offered by the Royal Agricultural Society, provided that these competitions are conducted under the conditions laid down by that Society. Where there is no local agricultural society, or the society does not conduct a competition, any farmer who desires to participate in the zone competition may do so by entering direct with the Royal Agricultural Society.

In each zone the Royal Agricultural Society awards a championship prize of £10 and a second prize of £2 10s. and in addition a special prize of £5 5s. is awarded to the competitor who obtains the highest calculated bushel yield per acre for all zones.

The conditions of the competitions require that the crop shall be grown on fallowed land; shall be not less than 50 acres in a compact and unbroken plot of one variety and shall be judged under the following scale of points:—

Yield	50 points.
Freedom from weeds	10 points
Freedom from disease	10 points
Freedom from admixture	15 points
Evenness of growth	15 points
Total	100 points

The points for yield are determined by taking quadrate samples systematically throughout the crop, threshing and weighing the grain, then the yield per acre is calculated and one point is allotted for each bushel yield per acre.



Since the inception of these competitions, the Judges have been Departmental Officers attached to the Wheat Branch. All the competing crops in any one zone are inspected and the awards made by the same judge.

The Season.—Following a period of four years of low rainfall, the 1939-40 season opened well with heavy rains in January when the wheatbelt, excepting the north-eastern portion, received falls well above the average. This was followed

by further heavy rains during the early part of February, when the whole of the wheatbelt benefited. These excellent falls served to replenish the supplies of subsoil moisture which were sadly depleted after the past four dry seasons.

Very little rain fell throughout the wheatbelt during the months of March and April. However, good falls were received during the early part of May, followed by warm conditions until the end of the month when further falls were recorded. These good rains resulted in an excellent germination of all crops.

The favourable seasonal conditions continued until the end of August, when a very dry September was experienced with the result that crops in the eastern portion of the wheatbelt began to suffer. Good rains during October relieved the position and the season finished very satisfactorily with average falls during November. The more westerly portions of the wheatbelt received excessive rain, but, generally speaking, the season can be considered as being very satisfactory.

A severe epidemic of rust occurred in the lower southern portion of the wheatbelt and this reduced both the yield of the competition crops and also the number of competitors in these areas.

The detailed awards made by the judges in the different zones are as follow:—

ZONE 1.

Judge: N. Davenport, Agricultural Adviser.

Competitors: Carnamah 5, Moora 5, Royal 1, Total 11.

The rainfall recorded at the centres concerned was as follow:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Carnamah	96	235	....	13	281	593	333	235	13	125	1,580	41	....	1,965
Three Springs....	116	307	32	4	197	503	324	243	16	132	1,415	21	2	1,897
Moora	183	375	1	64	380	389	539	333	19	99	1,759	155	2	2,539
Miling	148	332	65	....	293	410	470	301	13	111	1,598	*	....	*

* Not available.

The awards and cultural details of the leading crops are set out below:—

CARNAMAH AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 points.	10 points.	10 points.	15 points.	15 points.	100 pts.
Forrester, J. K.	Carnamah	Merredin	35	8	9	14	14	80
McDiamond, R.	do.	Bencubbin....	32	9	8	14	13	76
Clark, R. W.	do.	Nabawa	28	9	9	14	12	72
Gersch, H. E.....	Winchester	Dan	27	9	9	13	14	72
Niven, R.	Carnamah	Merredin	29	9	9	14	12	73

Mr. J. K. Forrester's crop of Merredin was grown on red-brown loam which originally carried York gum, salmon gum and black wattle. The land was ploughed during July, 1938, and cultivated with a disc implement during August. A rigid tyne implement was used for cultivating during October and February. The crop was sown on 20th May with a rigid tyne cultivator-drill and harrowed immediately afterwards. Seed and superphosphate were applied at 45 lb. and 130 lb. per acre respectively.

The crop of "Bencubbin" entered by Mr. M. McDiamond was grown on salmon gum and York gum country which had been under cultivation for a number of years. It was ploughed during early September, 1938, with a disc cultivating implement and cultivated with a spring tyne implement during October, 1938, February, 1939, and immediately prior to seeding. A combined cultivator drill was used for the seeding operation which was carried out during the second week of May. Seed and superphosphate were applied at 45 lb. and 90 lb. per acre respectively.

MOORA AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 points.	10 points.	10 points.	15 points.	15 points.	100 pts.
Ward, H. T. & Son	Namban	Ghurka	38	8	8	12	13	79
Black, T. A.	Moora	Bencubbin....	34	9	8	14	13	78
Smart, E. F.	Miling	Gluclub	32	9	9	13	13	76
Hockridge, W. J.	Moora	Sword	28	8	8	14	11	69
Seymour, H.	Miling	Ghurka	27	8	8	12	13	68

The first prize was awarded to Messrs. H. T. Ward and Son's crop of "Ghurka" grown on land originally timbered with York gum and jam. The land was broken up with a rigid tyne implement in early August, 1938, and cross-worked with the same implement in February after heavy rains. It was seeded during the middle of May, using a rigid tyne cultivator-drill and seed and superphosphate were applied at 70 lb. and 100 lb. per acre, respectively.

The crop of "Bencubbin" entered by T. A. Black was grown on land, originally timbered with York gum and salmon gum, which had been cleared for a number of years. It was ploughed during July, 1938, with a mouldboard implement, and cultivated with a springtyne cultivator immediately prior to seeding with a combined cultivator drill during the first week in May. Seed and superphosphate were applied at 60 lb. and 90 lb. per acre respectively.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Williamson, A. M.	Three Springs	Royal	Merredin	36	9	9	14	13	81
Forrester, J. K.	Carnamah	Carnamah	do.	35	8	9	14	14	80
Ward, H. T., & Son	Namban	Moora	Ghurka	38	8	8	12	13	79
Black, T. A.	Moora	do.	Bencubbin....	34	9	8	14	13	78
McDiamond, R.	Carnamah	Carnamah	do.	32	9	8	14	13	76

Mr. A. M. Williamson's crop of "Merredin" which won the zone championship was grown on York gum country which had been under cultivation for a number of years. The land was ploughed in July, 1938, with a disc implement, cultivated with a rigid tyne implement during August and seeded with a rigid tyne cultivator-drill during the third week in May. Seed and superphosphate were applied at 43 lb. and 112 lb. per acre respectively.

ZONE 2.

Judge: F. V. Knapp, Agricultural Adviser.

Competitors: Royal 2, Perenjori 1, Total 3.

The rainfall at Damboring and Perenjori for the year 1939 was as follow:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Damboring	91	310	....	37	328	321	279	125	12	63	1,128	119	....	1,685
Perenjori	175	256	18	3	255	499	344	189	4	132	1,423	49	....	1,924

Tables showing the judge's awards and cultural details of leading crops are set out below:—

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
England, W. H.	Perenjori	Perenjori	Bencubbin....	34	8	9	14	14	79
Borrett, R.	Damboring	Royal	do.	32	9	9	13	14	77
Bradford, R.	do.	do.	Gluclub	20	8	9	12	13	62

Mr. W. H. England's crop of "Bencubbin," which was awarded first place, was grown on land which had previously been timbered with salmon gum and York gum and had been cleared for a number of years. It was ploughed in July with a heavy disc implement and springtyne cultivated in March and again in April. Seed and superphosphate were applied with a combined cultivator drill during early May, the rates being 40lb. and 90lb. per acre, respectively.

The crop of "Bencubbin" entered by R. Borrett, was grown on salmon and York gum timber country, which had been cleared for a number of years. This land was ploughed during June and July with a disc cultivating plough to a depth of 3½ inches and springtyne cultivated in October and again in February. A combined cultivator drill was used for seeding, which was carried out during the middle of May, the rates of seed and superphosphate being 45lb. and 110lb. per acre, respectively.

ZONE 3.

Judge: F. L. Shier, Agricultural Adviser.

Competitors: Dowerin, 2; Ballidu, 7; Wyalkatchem, 7; total 16.

The rainfall recorded at the centres in this zone was as hereunder:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Dowerin	31	486	1	66	402	358	353	290	10	118	1,531	227	22	2,364
Wyalkatchem....	56	414	5	85	273	260	352	192	17	209	1,303	143	....	2,006
Dukin	51	305	....	50	230	212	189	165	10	217	1,023	81	4	1,514
Ballidu	91	343	3	59	322	375	319	162	5	142	1,325	115	....	1,936
Wongan Hills....	73	435	....	70	343	355	371	259	7	103	1,438	89	2	2,107

The judge's awards, together with cultural details of the leading crops, are set out below:—

BALLIDU AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 points.	10 points.	10 points.	15 points.	15 points.	100 pts.
Knapp, J.	Ballidu	Bencubbin	35	9	9	13	14	80
Ackland, J. H. (jun.)	Wongan Hills	do.	27	9	9	14	13	72
Mt. Rupert Pastoral Co.	do.	Gluclub	28	9	9	13	13	72
Goodie, H.	Ballidu	Golden King	26	9	8	13	13	69
Petchell, R.	do.	Gluclub	25	9	9	13	13	69
Maley, M.	do.	Bencubbin	25	9	9	13	13	69
Carter, F.	Kondut	do.	23	9	8	13	12	65

Mr. J. Knapp's winning crop of "Bencubbin" was grown on gimlet, morrell and York gum timber country which had been cleared for over twenty years. The land was broken up in July with a rigid tyne implement, cultivated in August and February with a springtyne cultivator and seeded during the middle of May with a combined cultivator drill. Seed and superphosphate were applied at 45lb and 90lb. per acre, respectively.

The crop of "Bencubbin" entered by Mr. J. H. Ackland, jnr., was grown on gimlet and morrell timber country which had been cleared for a number of years and cropped on the three-year system. The land was broken up in June with a rigid tyne implement, cultivated in September with the same implement, then harrowed and cultivated again in November and March with a springtyne implement. Seeding was carried out during the third week in May; seed and superphosphate were applied at the rates of 50lb. and 112lb. per acre, respectively.

The Mt. Rupert Pastoral Company's crop of "Gluclub," which tied for second place, was grown on salmon gum, morrell and gimlet timber country that had been cleared for a number of years. It was ploughed in July, 1938, with a mouldboard plough, cultivated in August, ploughed back in September with a disc cultivating plough and again cultivated with a springtyne implement in April. A combined cultivator drill was used for seeding, 60lb. seed and 180lb. superphosphate per acre being applied. The crop was harrowed after seeding in order to destroy the weed growth.

WYALKATCHEM AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel.)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 points.	10 points.	10 points.	15 points.	15 points.	100 pt
Errey, A. D.	Wyalkatchem	Bencubbin	36	9	9	14	14	82
Metcalf, E. A.	do.	do.	36	9	8	14	14	81
Maitland, C. W.	do.	do.	29	9	9	14	14	75
Lehman, C. E.	Dukin	Gluclub	27	9	9	14	13	72
Lawrence, A. E.	Wyalkatchem	Bencubbin	28	8	9	14	13	72
Riches, G. H.	do.	Nabawa	25	8	9	13	13	68
Geise, E. E.	do.	Gluyas Early	20	9	9	14	14	66

The winning crop of "Bencubbin" was grown by Mr. A. D. Errey on old land which had previously been timbered with gimlet and salmon gum. It was ploughed in June, 1938, with a disc plough, cultivated in September with a rigid tyne implement and seeded during early May with a combined cultivator drill. Seed and superphosphate were applied at 45lb. and 112lb. per acre, respectively.

Mr. E. A. Metcalf's crop of "Bencubbin" was grown on old land that had been broken up while dry in August, 1938, with a rigid tyne implement. It was cultivated with the same implement in February and March and seeded during the middle of May with a combined cultivator drill. Seed and superphosphate were applied at 45lb. and 118lb. per acre respectively.

The variety "Bencubbin" also gained third place, the crop being grown by Mr. C. W. Maitland on old land which was ploughed in late June, 1938, with a disc plough, reploughed with the same implement in September and cultivated in March. Seed and superphosphate were applied at 50lb. and 110lb. per acre, respectively.

DOWERIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield 1 pt. per Bushel.)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 points.	10 points.	10 points.	15 points.	15 points	100 pts.
Willmott, H. I.	Dowerin	Bencubbin	24	9	9	14	13	69
Thomas, T.	do.	do.	20	8	9	13	13	63

The crop of "Bencubbin" grown by Mr. H. I. Willmott was on land originally timbered with mallee, salmon gum and York gum. It was ploughed in late June, 1938, with a disc plough, cultivated in August and February with a springtyne cultivator and seeded during the third week of May with a rigid tyne cultivator-drill. Seed and superphosphate rates were 45lb. and 112lb. per acre, respectively.

Mr. T. Thomas' crop of "Bencubbin" was grown on mallee and jam timbered country, which had been cleared for a number of years. It was ploughed in July, 1938, with a disc cultivating plough and then ploughed back with the same implement in March. Seed and superphosphate were applied at 42lb. and 90lb. per acre, respectively, during the middle of May, a combined cultivator-drill being used for this operation.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush.)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Errey, A. D.	Wyalkatchem	Wyalkatchem	Bencubbin	36	9	9	14	14	82
Metcalf, E. A.	do.	do.	do.	36	9	8	14	14	81
Knapp, J.	Ballidu	Ballidu	do.	35	9	9	13	14	80
Ackland, J. H. (jun.)	Wongan Hills	do.	do.	27	9	9	14	13	72
Mt. Rupert Pastoral Co.	do.	do.	Gluclub	28	9	9	13	13	72
Willmott, H. I.	Dowerin	Dowerin	Bencubbin	24	9	9	14	13	69
Thomas, T.	do.	do.	do.	20	8	9	13	13	63

ZONE 4.

Judge: W. M. Nunn, Agricultural Adviser.

Competitors: Mt. Marshall, 17; Nungarin and Eastern Districts, 4; Wialki Branch Wheatgrowers' Union, 4; total, 25.

The rainfall recorded at the centres concerned was as follow:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Wialki	58	205	3	22	187	256	255	169	12	129	1,008	112	....	1,408
Beacon	56	348	14	8	184	280	240	157	3	137	1,001	*	*	*
Mandiga	22	259	3	54	130	206	216	140	22	149	863	198	....	1,399
Bencubbin	22	271	21	60	111	185	181	115	10	131	733	135	....	1,242
Nungarin	17	317	....	66	193	236	225	159	10	169	992	147	2	1,541

* Not available.

The awards and cultural details of the leading crops are set out below:—

MT. MARSHALL AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Totals.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pt.
Anderson Bros.	Wialki	Bencubbin	25	9	9	14	14	71
Stark, J. A.	Beacon	do.	24	8	9	14	13	68
Hawthorne, H. W.	do.	do.	23	8	9	14	13	67
Hammond, A.	Mandiga	do.	22	8	9	14	14	67
Gillett, B. M.	Bencubbin	do.	23	8	9	14	12	66
Shipway, J. B.	Beacon	do.	20	8	9	14	12	63
Manton, H. W.	do.	do.	20	9	9	12	12	62
Walters, R. J.	Bencubbin	do.	17	8	9	14	14	62
Gobbart, W. J.	Gabbin	do.	18	7	9	14	12	60
Perry Bros.	Bencubbin	Gluyas Early	18	9	7	14	12	60
Hopwood, B. W. G.	do.	Bencubbin	18	7	8	14	13	60
Collins, S. G.	do.	do.	18	6	9	14	12	59
Clarke, J. & W. M.	Wialki	do.	17	7	9	14	11	58
Burnham, E. I.	Beacon	do.	19	7	9	11	12	58
Taylor, E. A.	do.	do.	16	8	9	13	12	58
Wright, J. W.	Bencubbin	do.	18	6	9	12	12	57
Chamberlain, J. W.	Beacon	do.	16	6	9	13	11	55

The winning crop of "Bencubbin" entered by Messrs. Anderson Bros., was grown on salmon gum timber country which had been under cultivation for a number of years. It was ploughed in July, 1938, with a disc cultivating plough, cultivated in September with a springtyne implement and again, in April, with a disc cultivating plough. Seeding took place during first week of May, when 40lb. of seed and 90lb. of superphosphate per acre were applied.

Mr. J. A. Stark's crop of "Bencubbin" was grown on salmon gum and pine timber country, which had been cleared for a number of years. It was ploughed in August, 1938, with a disc implement, cultivated in October with a springtyne

implement and seeded during the second week of May. Seed and superphosphate were applied at 34lb. and 70lb. per acre, respectively.

The variety "Bencubbin" also gained third place, being entered by Mr. H. W. Hawthorne and grown on land which had originally been timbered with salmon gum and mallee. The land was ploughed during June, 1938, with a disc implement, re-disced in August and then seeded during the latter part of May. Seed and superphosphate were applied at the rate of 30lb. and 90lb. per acre, respectively.

NUNGARIN AND EASTERN DISTRICTS AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Watson Bros.	Nungarin	Bencubbin	26	7	9	14	13	69
Philbey, F. G.	do.	Gluyas Early	21	9	9	14	12	65
Creagh Bros.	do.	Bencubbin	23	7	8	14	11	63
Johnson, J. H., & Son	do.	Noongaar	19	9	8	14	13	63

Messrs. Watson Bros. winning crop of "Bencubbin" was grown on old land previously carrying salmon gum and gimlet timber. It was ploughed in July, 1938, with a disc implement, springtyne cultivated in September and March and seeded during the middle of May. Seed and superphosphate were applied at 45lb. and 90lb. per acre, respectively.

The crop of "Gluyas Early" grown by Mr. F. G. Philbey was on old land originally timbered with salmon gum and gimlet. It was broken up in June, 1938, with a rigid tyne implement, cultivated with the same implement in April and then seeded during the middle of May. Seed and superphosphate were applied at 50lb. and 112lb. per acre, respectively.

WIALKI BRANCH WHEATGROWERS' UNION.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Anderson Bros.	Wialki	Bencubbin	25	9	9	14	14	71
Miguel, J. A.	do.	do.	23	8	9	13	13	66
Clarke, J. & W. M.	do.	do.	17	7	9	14	11	58
Arnold, J. P. G.	do.	Noongaar	15	8	9	14	12	58

Mr. J. A. Miguel's crop of "Bencubbin" was grown on salmon gum, mallee and titree timber country which had been cropped for five years. It was ploughed in June, 1938, and again in July, 1938, with a disc implement and cultivated towards the end of March with a springtyne implement. Seeding took place during the middle of April when 30 lb. seed and 60 lb. superphosphate per acre were applied.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Anderson Bros.	Wialki	Mt. Marshall	Bencubbin	25	9	9	14	14	71
Watson Bros.	Nungarin	Nungarin and Eastern Districts	do.	26	7	9	14	13	69
Stark, J. A.	Beacon	Mt. Marshall	do.	24	8	9	14	13	68
Miguel, J. A.	Wialki	Wialki	do.	23	8	9	13	13	66
Philbey, F. G.	Nungarin	Nungarin and Eastern Districts	Gluyas Early	21	9	9	14	12	65

ZONE 5.

Judge: W. M. Nunn, Agricultural Adviser.

Competitors: Bruce Rock, 8; Royal, 3; total, 11.

The rainfall for the year at the centres concerned is set out below:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Bruce Rock	39	380	....	46	241	207	320	178	17	153	1,116	216	16	1,813
Belka	14	374	....	54	240	236	335	238	10	220	1,279	*	*	*

* Not available.

The awards and cultural details of the leading crops are set out hereunder:—

BRUCE ROCK AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Ellis, E. G. & M. P.	Bruce Rock....	Gluclub	39	8	9	13	13	82
Robinson, W.....	Babakin	do.	36	9	9	13	13	80
Strange, P. A.	Bruce Rock....	do.	35	8	9	14	14	79
Perkins, C. C.	Belka	Bencubbin....	34	7	9	14	13	77
Buller, A. M.	Bruce Rock....	Gluclub	33	9	9	13	13	77
Wilkins, H. W.	do.	do.	29	8	9	14	14	74
Allen, E. M.	do.	Totadgin	31	8	9	14	11	73
Allen, K.	do.	Noongaar	28	7	8	11	13	67

Messrs. E. G. and M. P. Ellis' crop of "Gluclub" was grown on old land originally timbered with jam, York gum and salmon gum. The land was ploughed in June with a disc implement, rigid tyne cultivated twice in September and seeded towards the end of April. Seed and superphosphate were applied at 50 lb. and 90 lb. per acre, respectively.

The second prize was awarded to Mr. W. Robinson's crop of "Gluclub," grown on country originally timbered with gimlet, salmon gum and York gum. The land was broken up in June with a rigid tyne implement, cultivated with a disc cultivating plough in August and again in March with a rigid tyne implement. Seed and superphosphate were applied at 45 lb. and 90 lb. per acre, respectively.

The crop of "Gluclub" entered by Mr. P. A. Strange was grown on country originally timbered with gimlet, morrell and salmon gum, which had been under cultivation for a number of years. The land was broken up in July, 1938, with a rigid tyne implement, cultivated in September and October with the same implement and seeded during the latter part of April. Seed and superphosphate were applied at 50 lb. and 100 lb. per acre, respectively.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Ellis, E. G. and M. P.	Bruce Rock	Bruce Rock	Gluclub	39	8	9	13	13	82
Teasdale, H. W.	Merredin	Royal	Bencubbin....	37	8	9	13	14	81
Robinson, W.	Babakin	Bruce Rock	Gluclub	36	9	9	13	13	80
Diver, L. C.	Kellerberrin	Royal	Bencubbin....	34	7	9	14	13	77
Kay, J.	Baandee	do.	Noongaar	20	8	9	14	14	65

Mr. H. W. Teasdale's crop of "Bencubbin" was awarded second place in the Zone Competition. It was grown on jam, gimlet and salmon gum timber country which had been under cultivation for a number of years. It was broken up in June with a rigid tyne implement, cultivated with the same implement in September and February and then seeded during the third week in May. Seed and superphosphate were applied at 45 lb. and 100 lb. per acre, respectively.

ZONE 7.

Judge: A. S. Wild, Agricultural Adviser.

Competitors: Lake Grace, 7; Kulin, 11; Kukerin, 7; Royal, 2; total, 27.

The rainfall recorded during the year at the centres concerned was as follow:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Lake Grace	401	228	3	24	456	190	426	155	25	292	1,544	148	....	2,348
Pingaring	145	229	....	57	335	249	328	195	10	154	1,271	194	*	*
Kulin	40	250	2	27	535	205	352	186	15	289	1,582	224	4	2,129
Kondinin	8	261	3	45	328	212	296	144	11	307	1,298	120	1	1,736
Kukerin	427	134	18	25	317	211	485	225	34	239	1,511	136	8	2,259
Dumbleyung	224	191	3	25	341	270	489	282	53	205	1,640	105	4	2,192
Tarin Rock	615	173	....	18	440	152	430	226	21	229	1,498	*	*	*
Hyden	161	425	5	37	443	117	328	208	23	241	1,360	240	3	2,231
Karlgarin	48	320	4	39	356	204	327	218	16	285	1,406	224	....	2,041

* Not available.

The awards and cultural details of the leading crops are set out below:—

LAKE GRACE AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Carruthers, W.	Lake Grace	Gluclub	36	8	9	13	14	80
Pelham, G. H.	do.	do.	33	9	8	14	14	78
Fleay, N. V.	Pingaring	do.	36	9	7	12	13	77
Coad, H. J.	Lake Grace	do.	32	9	8	13	14	76
Kay, W.	do.	do.	34	8	8	13	13	76
Darby, A. H.	do.	do.	31	8	8	14	13	74
Turner, G.	Pingaring	do.	26	8	8	13	13	68

The winning crop of "Gluclub" entered by Mr. W. Carruthers was grown on land that had previously been timbered with gimlet and had been cleared for a number of years. It was ploughed in June, 1938, with a disc implement, rigid-tyne cultivated in August, September and again in March. A combined cultivator-drill was used for seeding during the last week in April, when seed and superphosphate were applied at 52 lb. and 90 lb. per acre, respectively.

Mr. G. H. Pelham's crop of "Gluclub" was grown on land which had been cleared of salmon gum and mallee timber for approximately 20 years. A mould-board implement was used for ploughing up the land during June and it was then cultivated with a rigid-tyne implement in August, 1938, and again in early May, 1939. It was planted during the second week of May with a combined cultivator-drill, seed and superphosphate being applied at 62 lb. and 92 lb. per acre, respectively.

The third place went to Mr. N. V. Fleay's crop of "Gluclub," grown on morrell and salmon gum timber country which had been cleared for a number of years. It was ploughed in July, 1938, with a disc implement, spring-tyne cultivated in October and again in April, then seeded during the second week in May with a combined cultivator-drill. Seed and superphosphate were applied at 42lb. and 85lb. per acre, respectively.

KULIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Scadding, W. W. M.	Jilakin	Gluclub	37	9	8	12	13	79
Biglin, H. W.	Kondinin	Bencubbin....	34	8	8	14	14	78
Freebairn, R.	Jilakin	do.	34	9	8	13	13	77
Scadding, N. A.	do.	Gluclub	35	9	8	12	13	77
Carmody, T.	do.	Sword	35	8	7	13	13	76
Young, A. J.	Kondinin	Gluyas Early	31	8	9	14	14	76
Freebairn, F. S.	Kulin Rock....	Bencubbin....	32	9	8	13	13	75
Parker, C. W.....	Jilakin	do.	32	8	7	13	14	74
Repacholi, D.....	Kondinin	do.	30	9	8	13	14	74
Bowey, P. J.	Kulin	Gluclub	32	8	7	13	13	73
Sykes, H. J.	Kondinin	Bencubb n....	29	8	8	14	14	73

The crop of "Gluclub" entered by Mr. W. W. M. Scadding was the second crop on land which had previously been timbered with blackbutt, morrell and boree. The land was ploughed in July, 1938, with a disc implement to a depth of three inches, disced to a depth of two inches in September, and again, just prior to seeding, with a combined cultivator-drill during the fourth week in April. Seed and superphosphate were applied at 60 lb. and 110 lb. per acre, respectively.

Mr. H. W. Biglin's crop of "Bencubbin" was on old land which had originally been timbered with salmon gum, gimlet and morrell. The land was broken up during June, 1938, with a rigid tyne implement, cultivated with the same implement in August, springtyne cultivated in February and seeded during the last week in April with a combined cultivator-drill. Seed and superphosphate were applied at 50lb. and 95lb. per acre, respectively.

Mr. R. Freebairn's crop of "Bencubbin" was grown on country originally timbered with morrell. It was ploughed in June, 1938, with a disc implement, cultivated with a rigid tyne implement in September, with a springtyne cultivator in February and seeded during the first week in May with a combined cultivator-drill. Seed and superphosphate were applied at 60lb. and 112lb. per acre, respectively.

KUKERIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Bennett, A. F.	Dumbleyung	Gluclub	41	9	9	13	14	86
Faulkner, W. J.	North Kukerin	Bencubbin....	38	8	8	13	14	81
English, A. R.	Kukerin	do.	33	9	8	13	14	77
English, J. C.	Merilup	Gluclub	27	9	8	13	14	71
Fitton, J.	Tarin Rock....	do.	28	8	7	13	13	69
Gard, T.	Kukerin	do.	24	9	8	13	13	67
Kellow, J.	North Kukerin	Bencubbin....	23	9	8	13	13	66

Mr. A. F. Bennett's crop, although eligible for entry in the Kukerin Agricultural Society's crop competition, was not eligible for competition in the Zone 7 Crop Competition conducted by the Royal Agricultural Society, owing to the fact that his property is situated in Zone 8.

The winning crop of "Gluclub" entered by Mr. A. F. Bennett was grown on salmon gum, gimlet, morrell and mallee country, which had been cleared for a number of years. The land was broken up in early August, 1938, with a rigid tyne implement, cultivated with the same implement in late August, springtyne cultivated three times during late April and early May, and seeded with a combined cultivator-drill during the last week in May. Seed and superphosphate were applied at 60lb and 100lb. per acre, respectively.

The second place went to Mr. W. J. Faulkner's crop of "Bencubbin," grown on salmon gum timber country, which had been cleared for a number of years. The land was broken up in July, 1938, with a rigid tyne implement, cultivated with the same implement in August, late February and early May, and seeded during mid-May with a combined cultivator-drill. Seed and superphosphate were applied at 43lb. and 120lb. per acre, respectively.

Mr. A. R. English's crop of "Bencubbin" was grown on old land which had previously been timbered with York gum, jam and gimlet. The land was broken up during the latter part of June, 1938, with a rigid tyne implement, cultivated with the same implement in August, spring-tyne cultivated in early October, February and again in April. A combined cultivator-drill was used for seeding the crop during the second week of May; seed and superphosphate were applied at 48lb. and 100lb. per acre, respectively.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Faulkner, W. J.	North Kukerin	Kukerin	Bencubbin....	38	8	8	13	14	81
Carruthers, W.	Lake Grace	Lake Grace	Gluclub	36	8	9	13	14	80
Scadding, W. W. M.	Jilakin	Kulin	do.	37	9	8	12	13	79
Biglin, H. W.	Kondinin	do.	Bencubbin....	34	8	8	14	14	78
Pelham, G. H.	Lake Grace	Lake Grace	Gluclub	33	9	8	14	14	78
English, A. R.	Kukerin	Kukerin	Bencubbin....	33	9	8	13	14	77
Marshall, H. J.	Hyden	Royal	do.	31	9	8	14	14	76
Biglin, E. J.	Karlgarin	do.	do.	31	8	9	14	13	75

ZONE 8.

Judge: F. V. Knapp, Agricultural Adviser.

Competitors: Quairading 10, Toodyay 8, Wickepin 7, Gnowangerup 8, Royal 3, Total 36.

The rainfall for the year at the centres concerned in Zone 8 is set out below:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Tot l.
Quairading	120	306	2	40	463	281	353	232	20	155	1,504	151	5	2,128
Toodyay	58	277	1	16	392	472	522	479	25	121	2,011	172	....	2,535
Bolgart	60	469	1	13	405	490	480	434	24	86	1,919	76	3	2,541
Wickepin	44	243	....	25	416	316	449	254	39	258	1,732	97	....	2,141
Gnowangerup	471	137	20	133	223	204	335	193	39	311	1,305	140	2	2,208
Borden	302	104	7	76	168	120	207	151	35	256	937	121	....	1,547
Toolibin	183	172	3	19	347	242	407	290	20	166	1,472	52	....	1,901

The awards and cultural details of the leading crops are set out hereunder:—

QUAIRADING AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Blake & Sons	Dangin	Merredin ..	28	9	8	14	13	72
Powell, G. J.	Quairading	Ranee 4H	27	9	8	14	12	70
Powell, N. F.	do.	do.	28	8	7	14	12	69
Ward, A.*	Dangin	Bencubbin....	26	8	8	14	13	69
Dall, S. C.	Quairading	Ranee 4H	26	8	7	14	13	68
Durack, F. J.*	do.	Gular	23	9	8	13	12	65
Dall, A. F.	do.	do.	19	8	8	14	13	62
Baikie, L. M.*	do.	Bencubbin....	20	9	6	14	12	61
Dall, R. W.	do.	Gluclub	22	8	7	11	12	60
Shenton, E. G.*	do.	Bencubbin....	19	8	7	14	11	59

* Not eligible for the Royal Agricultural Society's Zone 8 Crop Competition.

The winning crop of "Merredin" entered by Messrs. Blake & Sons was grown on salmon gum and gimlet land which had been cleared for a number of years. It was broken up in early July, 1938, with a rigid tyne implement to a depth of 3½ inches, cultivated with the same implement in September and springtyne cultivated in April, 1939. The crop was sown during the last week of May with a combined cultivator-drill. Seed was applied at 50 lb. per acre and superphosphate at 100 lb. per acre.

Mr. G. J. Powell's crop of "Ranee 4H" which was awarded second place was grown on land which had previously been timbered with gimlet and salmon gum. It was broken up in July, 1938, with a rigid tyne implement to a depth of 3½ inches and cultivated in September, 1938, and February, 1939, with the same implement. A combined cultivator drill was used for the seeding operation which was carried out during the middle of May. Seed and superphosphate were applied at the rates of 45 lb. and 112 lb. per acre, respectively.

The entry of Mr. N. F. Powell, which tied with that of Mr. A. Ward for third place, was planted on salmon gum and gimlet land. A rigid tyne implement was used for breaking up the land in July, 1938, and the same implement was used

for further cultivations in August and March. The variety "Ranee 4H" was sown with a combined cultivator-drill during the third week of May. Seed and superphosphate were applied at 40 lb. and 120 lb. per acre, respectively.

Mr. A. Ward's crop of "Bencubbin" was also grown on salmon gum and gimlet timber country which had been under cultivation for a number of years. A rigid tyne implement was used for breaking up the land during August, 1938, and the same implement was used for cultivating the land in October (twice) and again in April. A combined cultivator-drill was used for sowing the seed at 60 lb. per acre and the superphosphate at 90 lb. per acre.

TOODYAY AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel.)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Erickson, S. U.	Bolgart	Bencubbin....	32	9	8	14	13	76
Travers, L. E.*	do.	do.	32	8	8	13	13	74
Phillips, J. C.	Toodyay	Waratah	29	8	8	13	14	72
Erickson, S. U.*	Bolgart	Pusa IV.	26	9	9	14	14	72
Drake - Brockman, R.	Toodyay	Ghurka	26	9	9	13	13	70
Hayes, E. D. P.	do.	do.	25	9	9	12	13	68
Drake - Brockman, R.*	do.	do.	22	9	9	13	12	65
Pearse, R.	Wattening	Wannon	19	7	7	11	12	56

* Not eligible for the Royal Agricultural Society's Zone 8 Crop Competition.

The winning crop entered by Mr. S. U. Erickson was a crop of "Bencubbin" grown on land which had originally carried white gum and a little York gum. It was ploughed with a mouldboard plough in June, 1938, to a depth of 4½ inches and cultivated with a rigid tyne implement in March, 1939. The crop was sown in early May by means of a combined cultivator-drill, seed and superphosphate being applied at the rate of 50 lb. and 130 lb. per acre, respectively.

"Bencubbin" was the variety grown by Mr. L. E. Travers who gained second place. The land on which this crop was grown had been under cultivation for over 30 years and had originally been timbered with York gum and jam. It was ploughed with a mouldboard plough in late August, 1938, and cultivated with a rigid tyne implement in February, 1939, and again a fortnight before seeding, which was carried out during the early part of June with a combined cultivator-drill. Seed and superphosphate were applied at the rate of 45 lb. and 120 lb. per acre, respectively.

Mr. J. C. Phillips' crop of "Waratah" was on York gum and jam country which was mouldboard ploughed in July, 1939, to a depth of 3½ inches. No further cultivation was given and the seed was sown during the third week of May with a combined cultivator-drill. The rates of seed and superphosphate were 50 lb. and 90 lb. per acre, respectively.

WICKEPIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel.)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Hosken, J.	Wickepin	Free Gallipoli	31	9	8	14	14	76
McDougall, K., M., & C.	Tinkurrin	Marathon	30	9	9	14	13	75
Doncon, E. E.	Wickepin	Bencubbin....	26	9	8	14	13	70
Cockram & Ballard	Tinkurrin	Dundee	24	8	7	13	13	65
Ballard, D.	do.	Bencubbin....	20	9	8	14	13	64
Miller, G. H.	Toolibin	Rajah	20	9	8	13	13	63
Fleay, E. H. & Sons	Wickepin	Bencubbin....	20	8	8	14	12	62

Mr. J. Hosken's winning crop of "Free Gallipoli" was grown on land which had been cleared for nearly 30 years. It had been originally timbered with mallee, salmon gum and York gum and was the first crop for five years. The land was ploughed in July with a mouldboard plough, cultivated in October and March with a springtyne implement, and planted with a combined cultivator-drill during the third week of May, using 60 lb. seed and 90 lb. superphosphate per acre.

The second prize was awarded to Messrs. McDougall's crop of "Marathon" which was on morrell and York gum country that had been cleared for a number of years. It was ploughed in June with a mouldboard plough, and cultivated in October and April with a springtyne implement. A combined cultivator drill was used for seeding the crop during the middle of May, when seed and superphosphate were applied at the rates of 60 and 120 lb. per acre, respectively.

Mr. E. E. Doncon's crop of "Bencubbin" was grown on land which had been originally timbered with York gum, salmon gum and white gum, together with a little morrell and jam. It had been cleared for a number of years and is worked on a three-year rotation. During June, 1938, the land was ploughed with a disc cultivating plough and cultivated in September and March with a springtyne implement. Seeding operations were carried out during the middle of May with a combined cultivator drill; seed and superphosphate were applied at the rates of 50 lb. and 90 lb. per acre, respectively.

GNOWANGERUP AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel.)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Bagnall, E.	Borden	Sword	33	9	8	14	14	78
Thompson & Hill	Gnowangerup	Rajah	34	8	8	13	14	77
Moore, Owen	do.	Yandilla King	33	9	7	14	14	77
Wellard & Wellard	do.	Bencubbin....	32	9	7	14	14	76
Badman & King	South Borden	Ghurka	32	9	8	12	14	75
Pozzi, R.	Gnowangerup	Free Gallipoli	33	8	7	13	14	75
Parnell, R.	do.	do.	31	9	6	14	13	73
Formby & Co., Ltd.	do.	Bencubbin....	27	9	5	14	12	67

Mr. E. Bagnall's crop of "Sword" was grown on land that had been recently cleared of yate and jam timber. It was ploughed in August with a mouldboard plough and cultivated in May with a springtyne implement. Seeding operations were carried out during early June with a combined cultivator-drill, seed and superphosphate being applied at 45 lb. and 90 lb. per acre, respectively.

The crop of "Rajah Improved No. 3" entered by Messrs. Thompson & Hill was grown on salmon gum timber country which had been cleared for ten years and worked on a four-year rotation. It was ploughed in July, 1938, with a mouldboard plough to a depth of approximately 3½ inches, then springtyne cultivated in September and February. Seeding was carried out during the second week of May with 45 lb. seed and 120 lb. superphosphate per acre respectively.

Mr. Owen Moore's crop of "Yandilla King" was grown on morrell, York gum timber country which is worked on a three-year rotation and which had been cropped six times previously. It was ploughed in late August, 1938, with a mouldboard plough, cultivated five times with a springtyne implement during 1939, and seeded during the second week of May with a disc drill. Seed and superphosphate were applied at 58 lb. and 104 lb. per acre, respectively.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush.)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Bennett, A. F.	Dumbleyung	Royal	Gluclub	41	9	9	13	14	86
Bagnall, E.	South Borden	Gnowangerup	Sword	33	9	8	14	14	78
Moore, Owen	Gnowangerup	do.	Yandilla King	33	9	7	14	14	77
Thompson and Hill	do.	do.	Rajah	34	8	8	13	14	77
Erickson, S. W.	Bolgart	Toodyay	Bencubbin....	32	9	8	14	13	76
Frideaux, J. S.	Noman's Lake	Royal	do.	31	9	9	14	13	76
Hosken, J.	Wickepin	Wickepin	Free Gallipoli	31	9	8	14	14	76
McDougall, K., M. and C.	Tinkurrin	do.	Marathon	30	9	9	14	13	75
Phillips, J. C.	Toodyay	Toodyay	Waratah	29	8	8	13	14	72
Blake & Sons	Dangin	Quairading	Merredin	28	9	8	14	13	72
Gilchrist, W. H.	Weden	Royal	Bencubbin....	27	9	8	14	14	72
Powell, G. J.	Quairading	Quairading	Ranee 4H....	27	9	8	14	12	70

The crop which won the zone championship was entered by Mr. A. F. Bennett of Dumbleyung and was of the variety "Gluclub." This crop was grown on salmon gum, morrell, black mallee and gimlet country which had been under cultivation for 30 years and is worked on a five-year rotation. It was broken up in August, 1938, with a two-way cultivation, with a rigid tyne implement, cultivated in April and May with the same implement and seeded during the later part of May with a combined cultivator drill. Seed and superphosphate were applied at 60 lb. and 100 lb. per acre respectively.

ZONE 9.

There was only one entry in this zone, Mr. F. E. Daw, of Ravensthorpe, and this competitor was forced to withdraw his crop on account of it being badly affected with the disease "rust."

COMPETITORS.

There were 129 competitors in this year's crop competition, 118 entered through the seventeen District Agricultural Societies and 11 entered direct with the Royal Agricultural Society

The following table shows the number and the average yield obtained each year since the competitions were inaugurated:—

Year.	Number of District Agricultural Societies Competing.	Number of Competitors.	Average Yield of Competitors.	Average Yield for State.
			bushels.	bushels.
1921	...	15	25·0	10·4
1922	...	32	24·0	8·9
1923	12	82	29·0	11·4
1924	15	70	31·0	12·8
1925	13	59	22·5	9·7
1926	11	99	24·5	12·0
1927	10	100	26·9	12·1
1928	13	114	22·5	10·1
1929	12	156	21·7	11·0
1930	15	165	27·4	13·3
1931	13	110	27·4	13·1
1932	17	168	29·3	12·3
1933	17	130	27·2	11·7
1934	17	114	26·8	9·8
1935	16	97	24·8	9·2
1936	12	80	21·0	8·4
1937	15	138	25·7	11·9
1938	17	120	26·3	11·3
1939	17	129	27·5	12·6*

* Estimate.

"Bencubbin" was again the most outstanding variety in the competitions, comprising 60 of the 129 competing crops and giving an average yield of 26.3 bushels per acre. This variety also won seven of the seventeen district competitions as well as three of the seven zone championships. Twenty-five entries were of the variety "Gluclub," which was placed first in four district competitions, and three zone championships. The only other variety to win a zone champion-

ship was "Merredin," which also won three district competitions out of four entries. The number of entries of each variety was:—"Bencubbin," 60; "Gluclub," 26; "Ghurka," 6; "Merredin," "Gluyas Early" and "Noongaar," 4; "Free Gallipoli," "Sword," and "Ranee 4H," 3; "Rajah," "Gular" and "Nabawa," 2; "Yandilla King," "Totadgin," "Marathon," "Waratah," "Dan," "Golden King," "Pusa IV," "Dundee" and "Wannon," 1.

YIELDS.

The special prize of £5/5/ for the competitor obtaining the highest calculated yield per acre was awarded to Mr. A. F. Bennett, of Dumbleyung, who produced a calculated yield of 41 bushels per acre.

The winners of this prize since 1925 are as follows:—

	Bush. per acre.
1925—Hebiton & Sons, Three Springs—Nabawa	34
1926—Cumming Bros., Carnamah—Yandilla King	38
1927—A. W. Parkinson, Gnowangerup—Yandilla King ...	40
1928—A. W. Parkinson, Gnowangerup—Yandilla King ...	40
1929—C. E. Cockram, Pallinup—Yandilla King	46
1930—C. Smith & Sons, Yarding—Gluclub	43
1931—H. O. Beeck, Gnowangerup—Yandilla King	42
1932—F. S. Freebairn, Jilakin—Gluclub	47
1933—D. Davis, Gnowangerup—Bencubbin	43
1934—C. E. Cockram, Pallinup—Free Gallipoli	40
1935—E. Davis, Gnowangerup—Bencubbin	41
1936—C. E. Cockram, Pallinup—Free Gallipoli	30
1937—A. R. English, Kukerin—Bencubbin	41
1938 A. J. Tonkin & Sons, Coomberdale—Bencubbin ...	38
1938 B. J. Edmonds, Calcarra—Bencubbin	38
1938 R. G. Bennett, Dumbleyung—Gluclub	38
1939—A. F. Bennett, Dumbleyung—Gluclub	41

Of the 129 crops in this year's competition, 38 were calculated to yield 24 to 29 bushels, 40 from 30 to 35 bushels, 11 from 36 to 39 bushels, and one 41 bushels, per acre.

The list of competitors who obtained 35 bushels and over is given below.

Zone.	Competitor.	Address.	Society.	Variety.	Calculated Yield.
					bushels.
8	Bennett, A. F. ...	Dumbleyung ...	Kukerin ...	Gluclub ...	41
5	Ellis, E. G. & M. P. ...	Bruce Rock ...	Bruce Rock ...	Gluclub ...	39
1	Ward, H. T. & Son ...	Namban ...	Moora ...	Ghurka ...	38
7	Faulkner, W.	North Kukerin	Kukerin ...	Bencubbin ...	38
5	Teasdale, H. W. ...	Merredin ...	Royal ...	Bencubbin ...	37
7	Scadding, W. W. M. ...	Jilakin ...	Kulin ...	Gluclub ...	37
1	Williamson, A. M. ...	Three Springs...	Royal ...	Merredin ...	36
3	Errey, A. D.	Wyalkatchem...	Wyalkatchem	Bencubbin ...	36
3	Metcalf. E. A. ...	Wyalkatchem...	Wyalkatchem	Bencubbin ...	36
5	Robinson, W.	Babakin ...	Bruce Rock ...	Gluclub ...	36
7	Carruthers, W. ...	Lake Grace ...	Lake Grace ...	Gluclub ...	36
7	Fleay, N. V.	Pingaring ...	Lake Grace ...	Gluclub ...	36
3	Knapp, J.	Ballidu ...	Ballidu ...	Bencubbin ...	35
3	Forrester, J. K. ...	Carnamah ...	Carnamah ...	Merredin ...	35
5	Strange, P. A. ...	Bruce Rock ...	Bruce Rock ...	Gluclub ...	35
7	Scadding, N. A. ...	Jilakin ...	Kulin ...	Gluclub ...	35
7	Carmody, T.	Jilakin ...	Kulin ...	Sword ...	35

Local Crop Competitions, 1939.

I. Thomas, Superintendent of Wheat Farming.

In addition to the 50-acre crop competitions conducted by the Royal and District Agricultural Societies under the zone system, a number of local competitions were conducted and judged by Departmental Officers attached to the Wheat Branch.

The Carnamah, Koorda and Bruce Rock Agricultural Societies conducted fallow and crop competitions, the Wialki branch of the Wheatgrowers' Union conducted a 50-acre crop competition for the Bevan cup (the results for this competition are shown under Zone 4 of the Royal Agricultural Society's crop competition), and the Newdegate branch of the Returned Soldiers' League conducted a fallow, germination and crop competition.

The particulars of the respective competitions are as follows:—

CARNAMAH AGRICULTURAL SOCIETY.

Judge: N. Davenport, Agricultural Adviser.

The rainfall recorded at Carnamah during the year was as follows:—

				Growing Period.								
	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Carnamah	96	235	....	13	281	593	333	235	13	125	1,580	41	....	1,965

The judge's awards are shown in the following table:—

CARNAMAH AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield. (1 pt. per bush).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total for Fallow.	Grand Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	200 pts.
Forrester, J. K.	Carnamah	Merredin	35	8	9	14	14	85	165
Gersch, H. E.	Winchester	Dan	27	9	9	13	14	87	159
Niven, R.	Carnamah	Merredin	29	9	9	14	12	75	148
McDiamond, R.	do.	Bencubbin	32	9	8	14	13	70	146
Clark, R. W.	do.	Nabawa	28	9	9	14	12	72	144

Mr. J. K. Forrester's crop of Merredin was grown on a red brown loam which originally carried York gum, salmon gum and black wattle. The land was ploughed during July, 1939, and cultivated with a disc implement during August. A rigid tyne implement was used for cultivating the fallow during October and February. The crop was sown on May 20th with a rigid tyne cultivator-drill and harrowed immediately afterwards. Seed and superphosphate were applied at 45 lb. and 130 lb. per acre, respectively.

50-ACRE CROP AND FALLOW COMPETITION.

Conducted by Koorda Agricultural Society.

Judge: W. M. Nunn, Agricultural Adviser.

The rainfall recorded at Koorda during the year was as follows:—

				Growing Period.								
	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Koorda	42	283	3	42	213	242	199	129	10	156	949	127	3	1,449

The judge's awards are shown in the following table:—

KOORDA AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield. (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total for Fallow.*	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	200 pts.
Best, R. T.	Koorda	Bencubbin	28	8	9	14	13	88	160
Smith, C. H.	do.	do.	25	8	9	14	13	85	154
Hesford, A. J.	do.	Rajah	23	8	8	13	13	82	147
Price, J. W.	do.	Bencubbin	23	6	8	14	13	79	143

* Fallow section judged in March, 1939.

The combined fallow and crop competition was won by Mr. R. T. Best whose competing area was salmon gum, gimlet and titree country which had been cropped for a number of years. The land was ploughed in June, 1938, with a mouldboard plough, springtyne cultivated in February, 1939, and seeded during the middle of May with the variety "Bencubbin." Seed and superphosphate were applied at 48 lb. and 80 lb. per acre, respectively.

Mr. C. H. Smith's crop of "Bencubbin" was grown on salmon gum and gimlet country which had been cropped for many years. The land was ploughed in July, 1938, with a disc implement, cultivated with the same implement in September, springtyne cultivated in late March and seeded during late May with a combined cultivator-drill. Seed and superphosphate were applied at 45 lb. and 112 lb. per acre, respectively.

50-ACRE CROP AND FALLOW COMPETITION.

Conducted by Bruce Rock Agricultural Society.

Judge: W. M. Nunn, Agricultural Adviser.

The rainfall recorded at Bruce Rock during the year was as follows:—

					Growing Period.									
	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Bruce Rock	39	380	....	46	241	207	320	178	17	153	1,116	216	16	1,813

The judge's awards are shown in the following table:—

BRUCE ROCK AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield. (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total for Fallow.*	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	200 pts.
Ellis, E. G. & M. P.	Bruce Rock	Gluclub	39	8	9	13	13	88	170
Simmonds, J.	do.	Bencubbin	28	8	9	12	14	82	153
Boase, E. M.	do.	do.	26	9	9	13	11	78	146
Allen, K.	do.	do.	26	8	9	14	11	82	150
Buller, A. M.	do.	Noongaar	26	8	8	13	12	85	152
Fuchsbickler, M.	do.	Totadgin	25	7	9	12	13	80	146
Pimlott, S. H.	Kwolyin	do.	24	8	8	12	11	85	148

* Fallow section judged during March, 1939.

The combined fallow and crop competition was won by Messrs. E. G. and M. P. Ellis' crop of "Gluclub," grown on jam, York gum and salmon gum timber country which had been cleared for a number of years. The land was ploughed in June, 1938, with a disc implement, rigid tyne cultivated twice during September and seeded in the last week of April. Seed and superphosphate were applied at 50 lb. and 90 lb. per acre, respectively.

Mr. J. Simmonds' crop of "Bencubbin" was grown on gimlet, morrell and mallee timber country. The land was broken up in June, 1938, with a rigid tyne cultivator, harrowed in August, springtyne cultivated in September and March, and seeded during the middle of May. Seed and superphosphate were applied at 45 lb. and 90 lb. per acre, respectively

50-ACRE FALLOW, GERMINATION AND CROP COMPETITION.

Conducted by Returned Soldiers' League, Newdegate.

Judge: A. S. Wild, Agricultural Adviser.

The rainfall recorded during the year at the centres concerned was as follows:—

	Growing Period.—												
	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Newdegate	256	188	4	74	389	152	320	217	61	318	1,457	144	3	2,126
Lake King	316	223	....	71	282	196	284	142	15	216	1,135	166	....	1,911
Lake Camm	628	268	19	53	275	189	309	116	8	212	1,109	118	1	2,196
Holt Rock	385	320	....	35	255	154	226	125	21	182	963	140	....	1,843
Lake Magenta	267	211	16	78	272	143	397	159	58	186	1,215	211	....	1,998

The judge's awards are shown in Table I, page 20.

The cultural details of the leading crops are set out below:

Mr. F. M. McPhee's crop of "Gluclub" was grown on land which was originally timbered with salmon gum, mallee and gimlet, and had been cleared in 1931. The land was ploughed during June, 1938, with a disc implement, cultivated during August, 1938, and February, 1939, with a rigid tyne cultivator, and planted during the third week of May with a combined cultivator-drill. Seed and superphosphate were applied at 48 lb. and 120 lb. per acre, respectively.

The crop of "Bencubbin" entered by Mr. G. H. Atkins was grown on land similar to Mr. McPhee's, which had been cleared for 10 years. The land was ploughed during June, 1938, with a disc implement, cultivated in September and late in August with a rigid tyne implement, and seeded during mid-May with a combined cultivator-drill. Seed and superphosphate were applied at 50 lb. and 95 lb. per acre, respectively.

Mr. G. R. W. Hearn's crop of "Gluyas Early" was on land which had been cleared for a number of years, the original timber being salmon gum and gimlet. It was ploughed during early June, 1938, with a disc implement, rigid tyne cultivated in July, August, late September, and twice again early in 1939. A combined cultivator-drill was used for seeding during the second week of May. Seed and superphosphate were applied at 56 lb. and 112 lb. per acre, respectively.

TABLE I.

50 ACRE FALLOW, GERMINATION AND CROP COMPETITION.

NEWDEGATE RETURNED SOLDIERS' LEAGUE.

Competitor.	Address.	Variety.	Fallow Section.						Germination Section.				Wheat Crop Section.						Grand Total.
			Moisture.	Mulch.	Freedom from Weeds.	Preparation of Seed Bed.	Evenness.	Total.	Evenness of Germination.	Vigour of Growth.	Freedom from Weeds.	Total.	Yield.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.	
			40 pts.	10 pts.	10 pts.	20 pts.	20 pts.	100 pts.	25 pts.	15 pts.	10 pts.	50 pts.	50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	250 pts.
McPhee, F. M.	Lake Camm	Gluclub ...	38	9	9	18	18	92	23	13	9	45	25	8	8	10	12	63	200
Atkins, G. H.	Lake King	Bencubbin ...	37	9	8	19	17	90	23	13	8	44	25	9	8	10	13	65	199
Hearn, G. R. W.	Newdegate	Gluyas Early	36	8	7	19	18	88	22	13	7	42	25	9	9	12	14	69	199
Watson, G. F.	Lake Magenta	Gluclub	36	9	8	18	18	89	22	13	9	44	23	9	7	13	14	66	199
Gillett, S. E. T.	Newdegate	Bencubbin	38	8	7	19	19	91	23	13	8	44	24	7	7	12	12	62	197
Lloyd, E. ...	do.	Gluyas Early	36	8	7	18	18	87	22	13	7	42	24	8	9	13	14	68	197
Grant, E.	do.	do.	36	8	8	19	18	89	22	12	8	42	24	7	8	13	13	65	196
Hartley, A. H.	do.	Bencubbin	37	9	9	18	18	91	20	12	9	41	22	9	6	13	12	62	194
Hetherington, N.	Lake Camm	Gluyas Early	37	7	8	18	18	88	21	12	9	42	24	9	7	10	14	64	194
Francis, M. A.	Holt Rock	Sword	36	6	7	18	18	85	21	13	8	42	25	8	9	12	12	66	193
Kane, J. H. ...	Lake Magenta	Bencubbin	37	9	9	18	18	91	23	13	7	43	21	7	7	12	12	59	193
Brooker, H.	Newdegate	Gluclub	37	9	8	18	18	90	22	13	7	42	19	7	6	13	12	57	189
Tuck, G.	South Newdegate	Bencubbin	35	8	9	17	17	86	23	14	9	46	16	8	6	12	13	55	187
Hudson, G.	Lake Magenta	do.	36	8	7	18	18	87	24	13	8	45	15	7	6	13	13	54	186
Thomson, S. L.	Newdegate	do.	36	7	8	17	17	85	23	13	7	43	14	7	6	14	12	53	181

Field Experiments with Wheat and Oats, 1939, at the Agricultural Research Stations.

I. Thomas, Superintendent of Wheat Farming.

At each of the Research Stations located in the Wheat Belt, field experiments with wheat and oats are conducted each year. These Research Stations are widely separated and embrace a considerable variation of soil and climatic conditions.

The field experiments conducted cover a wide range and include such important phases as fallowing, depth and time of ploughing and frequency of cultivation. The most prolific varieties, the best time to plant, the most economical rates of seed and superphosphate to apply, and the effect of various fungicides upon the yields are also ascertained.

With but one or two minor exceptions the experimental plots are one-eighth of an acre in area. They are long and narrow, being one drill width wide, and measure 833 links by 15 links, and are replicated five times.

They are designed on the "three plot" system, the centre plot of each section (three plots) being the control—thus each varying factor is adjacent to a control plot.

The results of the Merredin and Yilgarn Research Stations are given below.

MERREDIN RESEARCH STATION.

J. H. Langfield, Farm Manager.

This station is located 160 miles from Perth on the Eastern Goldfields Railway, and is approximately in the centre of the main eastern wheatbelt. The major portion of the land is salmon gum and gimlet forest country.

THE SEASON, 1939.

The rainfall recorded at the station during 1939 and the average for the past 27 years is set out below:—

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total. for Year.
1939	....	347	....	54	192	250	242	154	12	169	1,019	169	....	1,589
Av., 27 years	52	44	105	89	127	181	180	152	84	78	802	41	50	1,183

Heavy rain storms were experienced on the 13th of February when 345 points were registered. Following these rains, no further falls of consequence were registered until early in May, when 165 points were recorded between May 4th and 10th. Until the middle of June fairly dry conditions were experienced, and seeding operations proceeded without interruption, being completed by 31st May.

Germination was excellent over the whole area under crop, and the initial rapid growth was sustained until the end of August. Rainfall during September was well below the average, and the hot, dry conditions checked the growth of all crops. Belated rains early in October, however, relieved the position and the crops matured under satisfactory conditions.

Except where the nature of an experiment required special treatment, the land on which the experimental plots were planted was ploughed to a depth of 3½-4 inches during June, July and the first half of August, 1938, with a disc cultivating

plough. In September the heavy soil was cultivated with a rigid-tyne implement and the lighter soils with a spring-tyne implement. Following the heavy rain storms in February, 1939, the whole area was worked with heavy harrows and seeding operations commenced in the last week of April.

FALLOW v. NON-FALLOW EXPERIMENT.

The object of this experiment is to ascertain the effect of fallowing upon the grain yield of the subsequent wheat crop.

The fallowed plots were ploughed in June, 1938, with a disc cultivating plough, cultivated with a rigid-tyne implement in September and again with the same implement immediately prior to seeding. The non-fallowed plots were ploughed on 15th May, 1939, with a disc cultivating plough and cultivated with a rigid tyne implement immediately prior to seeding.

Planted on 19th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 30th May, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Treatment.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1925–39.	Percentage Yields, 1925–39.
	bus. lb.	%	bus. lb.	%
Fallow	22 34	84	21 13	134
Non-fallow	26 54	100	15 46	100

The crops on the fallowed plots during 1939 were very heavy and rank and were severely damaged by storms in November, and in consequence a certain amount of grain was not recovered and this would account at least to some extent for the lower yields being obtained from these plots.

The average results over a period of 15 years, however, show that a definite increase in yield is obtained from planting the wheat crop on fallowed land.

DISC CULTIVATING PLOUGH v. RIGID TYNE CULTIVATOR.

The object of this experiment is to determine the effect of carrying out the initial operation of fallowing using a disc cultivating plough as compared with a rigid tyne cultivator. The resultant grain yield of the wheat crop is taken as a means of comparison.

For the requirements of the experiment, three plots are used, each plot being replicated three times.

Plot 1. Rigid tyne cultivated, once in June, 1938.

Plot 2. Disc cultivated, once in June, 1938.

Plot 3. Rigid tyne cultivated, twice in June, 1938.

After the initial workings which were 3½-4 inches deep, all the plots received similar cultivations.

Planted on 19th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 30th May, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Treatment.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1938–39.	Percentage Yields, 1938–39.
	bus. lb.	%	bus. lb.	%
Once Scarified	27 50	97	19 54	98
Disc Ploughed	28 30	100	20 20	100
Twice Scarified	26 22	92	18 58	93

The results for the two years that this experiment has been conducted indicate that there is no significant difference in grain yield between any of the above treatments. However, as the experiment has only been conducted for two years, these results cannot be taken as conclusive.

TIME OF PLOUGHING EXPERIMENT.

The object of this experiment is to ascertain whether the time of carrying out the initial operation of fallowing, viz., ploughing, has any effect upon the yield of the resultant wheat crop.

Planted on 19th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 30th May, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Time of Ploughing.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1930–39.	Percentage Yields, 1930–39.
	bus. lb.	%	bus. lb.	%
Mid-July, 1938	25 38	102	24 11	95
Mid-June, 1938	25 12	100	25 35	100
Mid-August, 1938	27 14	108	21 2	82

This year the late fallowed plots have shown to advantage; however, the average results over a period of ten years show that appreciably higher yields can be expected when the land is ploughed during the early winter months rather than during the later winter or early spring months.

MULCHING EXPERIMENT.

The object of this experiment is to determine to what extent and under what conditions the spring and summer cultivations of winter fallowed land is profitable.

To meet the requirements of the experiment, three plots were used, one being cultivated prior to seeding only, another cultivated during spring and before seeding, and the third cultivated in spring, again when required during summer, and prior to seeding.

Cultivations given each plot are as follow:—

Plot 1.—Cultivated on May 17th, 1939, with springtyne cultivator.

Plot 2.—Cultivated on September 12th, and again on May 17th, both times with a springtyne cultivator.

Plot 3.—Cultivated on September 12th, February 20th, April 4th, and again on May 17th, the springtyne implement being used each time.

Planted on 18th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 28th May, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Treatment.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1915–39.	Percentage Yields, 1915–39.
	bus. lb.	%	bus. lb.	%
Cultivated in spring after summer rains and before planting	26 58	107	21 18	102
Cultivated in spring and before planting	25 6	100	20 48	100
Cultivated before planting ...	24 24	97	19 50	96

This year's results show a slightly increased yield following the summer cultivations; this increase is possibly due to the heavy rains during February germinating the weeds and thus enabling them to be controlled by the summer

cultivations. The results since the inception of the experiment and experience in other parts of the wheatbelt, however, indicate that summer cultivations are not warranted unless weed growth cannot be controlled by stock, or heavy rain during the summer months has destroyed the soil mulch.

TIME OF PLANTING EXPERIMENT.

The object of this experiment is to determine the most suitable month for planting an early and a mid-season variety of wheat.

To meet the requirements of the experiment the variety Gluyas Early, an early maturing variety, was sown in mid-May, June and July, and the midseason maturing variety Nabawa was sown in mid-April, May and June.

Superphosphate—112 lb. per acre. Variety—Gluyas Early. Seed—45 lb. per acre

Date Planted.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1923–39.* bus. lb.	Percentage Yields, 1923–39.* %
Mid-June	27 20	92	19 45	88
Mid-May	29 46	100	22 31	100
Mid-July	15 36	52	12 12	54

* Excluding 1936.

Superphosphate—112 lb. per acre. Variety—Nabawa. Seed—45 lb. per acre.

Date Planted.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1929–39.* bus. lb.	Percentage Yields, 1929–39.* %
Mid-April	32 35	116	22 6	109
Mid-May	28 6	100	20 10	100
Mid-June	21 58	78	15 56	79

* Excluding 1936.

The results obtained this year, together with the average results over a period of 10 years indicate that in general the sowing of an early variety should be completed before the end of May, and a mid-season variety before the middle of May.

RATE OF SEEDING EXPERIMENT.

The object of this experiment is to determine the most economical rate to seed:—

1.—A mid-season, free stooling variety; and

2.—An early, sparse stooling variety of wheat.

The variety Nabawa was used in the first section and the variety Noongaar in the second, both being sown at the rates of 30, 45 and 60 lb. per acre.

FREE STOOLING VARIETY.

Planted on 25th April, 1939. Superphosphate—112 lb. per acre.
Germinated on 14th May, 1939. Variety—Nabawa.

Rate of Seed per Acre.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1913–39.* bus. lb.	Percentage Yields, 1913–39.* %
30 lb.	30 2	99	18 37	95
45 lb.	30 27	100	19 47	100
60 lb.	30 34	100	19 52	100

* Excluding 1914 and 1931.

SPARSE STOOLING VARIETY.

Planted on 31st May, 1939. Superphosphate—112 lb. per acre.
Germinated on 10th June, 1939. Variety—Noongaar.

Rate of Seed per Acre.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1915–39. bus. lb.	Percentage Yields, 1915–39. %
30 lb.	27 58	95	18 6	95
45 lb.	29 18	100	19 2	100
60 lb.	29 2	99	19 4	100

The results of this experiment indicate that there is no advantage to be gained by sowing more than 45 lb. of graded seed per acre in districts having similar conditions to Merredin.

RATE OF APPLICATION OF SUPERPHOSPHATE EXPERIMENT.

The object of this experiment is to determine the most profitable rate of superphosphate to apply to the wheat crop.

Section 1.

Planted on 18th May, 1939. Seed—45 lb. per acre.
Germinated on 28th May, 1939. Variety—Totadgin.

Rate of Superphosphate per Acre.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1929–39.* bus. lb.	Percentage Yields, 1929–39.* %
Nil	23 55	94	13 38	62
150 lb.	25 25	100	22 4	100
75 lb.	30 14	118	20 50	94

* Excluding 1936.

Section 2.

Planted on 18th May, 1939. Seed—45 lb. per acre.
Germinated on 28th May, 1939. Variety—Totadgin.

Rate of Superphosphate per Acre.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1929–39.* bus. lb.	Percentage Yields, 1929–39.* %
300 lb.	16 50	70	22 32	101
150 lb.	23 54	100	22 16	100
225 lb.	18 53	78	22 33	101

* 1936 excluded.

This year the plots in Section 2 (heavy rates) lodged badly following heavy rains in November and consequently the yields obtained were considerably reduced as much of the grain could not be recovered. This also applied to the control plot in Section 1 (light rates). Only slight lodging occurred in the plots receiving an application of 75 lb. per acre whilst the unmanured plots were unaffected in this direction.

However, the average results over a period of eight years indicate that the rate of superphosphate can be increased with advantage above 75 lb. per acre. Under present conditions the most economic rate on this class of soil is approximately 100 lb. per acre.

POTASH-NITROGEN EXPERIMENT.

The object of this experiment is to determine the effect upon the wheat crop of the application of:—

(a) a nitrogenous fertiliser;

(b) a nitrogenous plus a potassic fertiliser.

Sulphate of ammonia, a nitrogenous fertiliser, and sulphate of potash, a potassic fertiliser, were used in addition to superphosphate.

Planted on 23rd May, 1939. Seed—45 lb. per acre.
Germinated on 2nd June, 1939. Variety—Totadgin.

Rate of Fertiliser per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1932–39.	Percentage Yields, 1932–39
	bus. lb.	%	bus. lb.	%
112 lb. Superphosphate; 112 lb. Sulphate of Ammonia	28 30	102	20 1	101
112 lb. Superphosphate	27 52	100	19 45	100
112 lb. Superphosphate; 112 lb. Sulphate of Ammonia; 56 lb. Sulphate of Potash	27 54	100	19 44	100

Both the results for this year and the average results over the period of six years that the experiment has been conducted show that there is no significant increase in yield from applications of nitrogenous or potassic fertilisers on this type of country.

SEASONAL VARIETY TRIALS.

The objects of this experiment are:—

(a) to ascertain the most suitable month to plant the late, midseason, early and very early maturing varieties of wheat; and

(b) to determine the most prolific of each of the above types.

To meet the requirements of the experiment, three sections were required, viz.:—

1. Section 1, planted in mid April—representing early planting.
2. Section 2, planted in mid May—representing mid-season planting.
3. Section 3, planted in mid June—representing late planting.

In all sections the standard mid-season maturing variety Nabawa was planted as the control plot.

APRIL PLANTING.

Planted on 20th April, 1939. Superphosphate—112 lb. per acre.
Germinated on 14th May, 1939. Seed—45 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
Bencubbin	31 9	109	113*
Nabawa	28 29	100	100
Dundee	28 3	98	98†
Fedweb 1	21 9	73	73†
Nabawa	28 50	100	100
Hofed 1	16 14	56	56†

* Average 10 years. † First year of Trial.

MAY PLANTING.

Planted on 15th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 24th May, 1939. Seed—45 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields,
	bus. lb.	%	%
Bencubbin	25 4	110	112*
Nabawa	22 51	100	100
Dundee	17 25	76	76‖
M 47	18 18	81	98§
Nabawa	22 42	100	100
Gluyas Early	20 5	88	108†
Bungulla	23 50	100	115§
Nabawa	23 49	100	100
Totadgin	22 13	93	115‡
M 44	18 45	85	94§
Nabawa	22 6	100	100
Gular	24 27	111	111‖
M 53	19 42	88	103§
Nabawa	22 14	100	100
M 51	20 42	93	105§
Noongaar	22 22	110	104†
Nabawa	20 24	100	100
Geeralying	14 56	73	95*

* Average, 10 years. † Average, 11 years. ‡ Average, 8 years.
§ Average, 3 years. ‖ 1st year of Trial.

JUNE PLANTING.

Planted on 15th June, 1939. Superphosphate—112 lb. per acre.
Germinated on 28th June, 1939. Seed—45 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
M 51	23 54	116	116*
Nabawa	20 38	100	100
M 53	24 16	118	118*
M 52	22 58	112	112*
Nabawa	20 32	100	100
Noongaar	26 38	129	120§
Bencubbin	24 26	123	114‡
Nabawa	19 47	100	100
Bungulla	24 16	123	131†
Merredin	14 58	75	101‡
Nabawa	20 3	100	100
M 47	21 6	105	105*

* 1st year of Trial. † Average, 3 years. ‡ Average, 9 years.
§ Average, 11 years.

In the early planted section, the mid-season variety "Bencubbin" has again shown to advantage this year as it has done for the past 10 years, thus indicating its suitability for planting early in the season.

In the May (mid-season) planted plots the varieties "Bencubbin," "Bungulla," "Noongaar" and "Gular" all yielded well.

The average results over a number of years show that the varieties "Bencubbin," "Gluyas Early," "Bungulla," "Totadgin" and "Noongaar" have consistently yielded well.

In the June (late) planted section, with the exception of "Merredin," all varieties outyielded the control variety "Nabawa." Outstanding were the varieties "Noongaar," "Bungulla" and "Bencubbin," while the new crossbred varieties M51 and M52 also yielded well.

PREMIUM WHEAT VARIETY TRIAL.

The object of this experiment is to determine the most prolific of the Premium Wheat Varieties.

The standard variety "Nabawa" was used as control.

Planted on 26th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 6th June, 1939. Seed—45 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields, 1937–39.
	bus. lb.	%	%
Carrabin	22 35	89	91
Nabawa	25 17	100	100
Pusa 4	23 52	94	95
Pusa 113	15 57	64	73
Nabawa	25 1	100	100
Comeback	15 7	61	63

Of the varieties under trial, "Pusa 4" and "Carrabin" show to advantage; neither, however, equalled the control variety "Nabawa."

FUNGICIDE EXPERIMENT.

The object of this experiment is to determine the comparative effect of copper carbonate and two organic mercury compounds when used as fungicides, upon the germination, growth and grain yields of wheat and oat crops.

Planted on 23rd May, 1939. Superphosphate—112 lb. per acre.
Germinated on 2nd June, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Treatment.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1938–39	Percentage Yields, 1938–39.
	bus. lb.	%	bus. lb.	%
Mercury Compound A	27 36	99	20 28	104
Copper Carbonate	27 58	100	19 45	100
Mercury Compound B	28 3	100	20 5	102

The oat section of this experiment was so severely damaged by storms early in November that it could not be harvested.

The results since the inception of this experiment for both wheat and oats show that there is no significant difference in germination, growth or yield between the various treatments.

YILGARN RESEARCH STATION.

W. A. Human, Farm Manager.

This Station is located at Ghooli Siding, eight miles east of Southern Cross on the Eastern Goldfields Railway, and was established in December, 1926. It contains 4,943 acres, of which 3,500 are first class. The total area at present cleared is 1,635 acres.

THE SEASON 1939.

The following table shows the monthly rainfall registrations for the year, together with the averages for the previous 11 years:—

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
1939	146	138	....	71	168	170	210	153	15	138	854	259	5	1,473
Av., 1928–38	48	37	83	96	128	134	118	145	46	68	639	65	46	1,014

The good rains experienced early in May were, unfortunately, followed by a period of six weeks in which no rain of consequence was recorded. As a result, early sown crops germinated well but did not make satisfactory growth, while crops sown after the middle of May germinated very irregularly. Good rains were experienced during July and August and prospects were greatly improved, but the crops were given a further setback by dry conditions during September. The majority of the crops were seriously affected by tipping during September, and the October and November rains were too late to be of any value, except to the very late sown crops.

The paddock which contained the experimental block was originally timbered with salmon gum and gimlet. It was given uniform cultivation, except where the nature of the experiment required special treatment. The land was broken up in July and August, 1938, mainly with a disc cultivating plough. The land was subsequently cultivated with a rigid tyne implement in September, and again with a spring tyne cultivator in February and before seeding.

TIME OF PLOUGHING EXPERIMENT.

The object of this experiment is to determine what effect the time of ploughing (i.e., the initial operation of fallowing) will have on the resultant yield of the wheat crop.

Planted on 24th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 3rd June, 1939. Variety—Gluyas Early. Seed—40 lb. per acre.

Ploughed.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1933–39.* bus. lb.	Percentage Yields, 1933–39.* %
March, 1938	14 8	106	10 12	96
June, 1938	13 22	100	10 34	100
August, 1938	13 17	99	10 11	96

* Excluding 1934 and 1936.

Although the average results over the period of the experiment show no great difference between the treatments, the yields from the June ploughed plots are slightly higher than those from either March or August. Generally speaking, it is not possible to plough efficiently during either March or August, and consequently better work can be done during the early winter months.

It is, therefore, recommended as a result of experience at this and other Research Stations, that the initial operation of fallowing, i.e., ploughing, be carried out as early as possible after sufficient rain has fallen to enable the work to be carried out satisfactorily.

DEPTH OF PLOUGHING EXPERIMENT.

The object of this experiment is to determine the most economical depth to plough when fallowing for the wheat crop.

Planted on 23rd May, 1939. Superphosphate—112 lb. per acre.
Germinated on 3rd June, 1939. Variety—Gluyas Early. Seed—40 lb. per acre.

Depth of Ploughing.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1933–39.*	Percentage Yields, 1933–39.*
	bus. lb.	%	bus. lb.	%
2 inches	16 35	94	11 7	98
4 inches	17 36	100	11 18	100
6 inches	17 17	98	11 12	99

* Excluding 1934 and 1936.

The average results over a period of five years show that the depth of ploughing has no significant effect on the yield of the crop. Experience in this and other districts, however, has shown that land which has been ploughed to a depth of less than four inches requires additional subsequent cultivation to maintain the soil mulch and prepare a satisfactory seed bed.

Ploughing to a depth of four inches, when preparing land for the wheat crop is, therefore, recommended as being the most economical.

MULCHING EXPERIMENT.

The object of this experiment, which has been conducted since 1933, is to determine to what extent and under what conditions the cultivation of winter fallowed land during the spring and summer months is profitable.

To meet the requirements of the experiment three plots were treated, as follows:—

Plot 1.—Cultivated prior to seeding only (neglected fallow).

Plot 2.—Cultivated during spring and prior to seeding (ordinary fallow).

Plot 3.—Cultivated during spring, again when required during summer after 25 points of rain or over, and again prior to seeding.

Planted on 23rd May, 1939. Superphosphate—112 lb. per acre.
Germinated on 3rd June, 1939. Variety—Gluyas Early. Seed—40 lb. per acre.

Cultivated.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1933–39.*	Percentage Yields, 1933–39.*
	bus. lb.	%	bus. lb.	%
Before seeding only	12 50	95	10 26	97
In spring and before seeding ...	13 31	100	10 47	100
In spring, after summer rains, and before seeding	15 38	116	11 31	107

* Excluding 1936.

The results of this year's experiment and the average results over the past six years show that there is a slight increase in the wheat yield resulting from summer cultivations of the fallow. Summer cultivation, however, is only likely to be of economic advantage when it is necessary to destroy weeds, and to maintain an adequate soil mulch.

RATE OF SUPERPHOSPHATE EXPERIMENT.

The object of this experiment is to determine the most economical rate of superphosphate to apply to the wheat crop.

Section 1.

Planted on 22nd May, 1939. Seed—40 lb. per acre.
Germinated on 31st May, 1939. Variety—Gluyas Early.

Rate of Application of Superphosphate per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1929–39.*	Percentage Yields, 1929–39.*
	bus. lb.	%	bus. lb.	%
Nil	10 32	63	9 42	56
150 lb.	16 45	100	17 14	100
75 lb.	16 43	100	14 42	86

* Excluding 1936 and 1938.

Section 2.

Planted on 22nd May, 1939. Seed—40 lb. per acre.
Germinated on 31st May, 1939. Variety—Gluyas Early.

Rate of Application of Superphosphate per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1929–39.*	Percentage Yields, 1929–39.*
	bus. lb.	%	bus. lb.	%
225 lb.	11 9	92	13 55	102
150 lb.	12 5	100	13 39	100
300 lb.	11 12	93	14 0	102

* Excluding 1932 and 1936.

The average results over a period of nine years show that the optimum rate of application of superphosphate to the wheat crop in this district is approximately one hundredweight per acre.

TIME OF PLANTING EXPERIMENT.

The object of this experiment is to determine the most suitable month to plant:—

1.—A mid-season maturing variety.

2.—An early maturing variety.

The varieties used in seeding this experiment were:—

1.—Nabawa (a mid-season maturing variety).

2.—Gluyas Early (an early maturing variety).

Superphosphate—112 lb. per acre. Variety—Nabawa. Seed—40 lb. per acre.

Date Planted.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1929–39.*	Percentage Yields, 1929–39.*
	bus. lb.	%	bus. lb.	%
April 16th, 1939	11 39	126	16 55	107
May 16th, 1939	9 14	100	15 48	100
June 16th, 1939	7 33	82	10 14	65

* Excluding 1936 and 1938.

Superphosphate—112 lb. per acre. Variety—Gluyas Early. Seed—40 lb. per acre.

Date Planted.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1929–39.*	Percentage Yields, 1929–39.*
	bus. lb.	%	bus. lb.	%
June 16th, 1939	11 26	84	12 24	74
May 16th, 1939	13 33	100	16 39	100
July 18th, 1939†	6 24	47	6 51	41

* Excepting 1936 and 1938. † July section discarded in 1937 due to destruction by grasshoppers.

This year's results again emphasise the necessity of completing the planting of a mid-season maturing variety before the middle of May, and of an early maturing variety before the end of May.

RATE OF SEEDING EXPERIMENT.

The object of this experiment is to determine the most economical rate of seeding with:—

1.—A mid-season maturing, free stooling variety;
2.—An early maturing, sparse stooling variety.

In section 1 the variety Nabawa was used, and in section 2 the variety Noongaar.

FREE STOOLING VARIETY.

Planted on 18th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 29th May, 1939. Variety—Nabawa.

Rate of Seed per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1937–39.*	Percentage Yields, 1937–39.*
	bus. lb.	%	bus. lb.	%
30 lb.	5 1	81	5 46	87
45 lb.	6 10	100	6 37	100
60 lb.	6 26	104	6 42	101

* Excluding 1938.

SPARSE STOOLING VARIETY.

Planted on 29th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 26th June, 1939. Variety—Noongaar.

Rate of Seed per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1937–39.*	Percentage Yields, 1937–39.*
	bus. lb.	%	bus. lb.	%
30 lb.	9 15	88	7 57	92
45 lb.	10 32	100	8 40	100
60 lb.	11 15	107	9 2	104

* Excluding 1938.

The results of this experiment demonstrate that there is no advantage to be gained by sowing at a greater rate than 45 lb. per acre of graded seed.

POTASH-NITROGEN EXPERIMENT.

The object of this experiment is to determine the effect upon the yield of the wheat crop of an application of:—

(i) a nitrogenous fertiliser;
(ii) a nitrogenous plus a potassic fertiliser;

in addition to the usual application of superphosphate.

For the purpose of the experiment, the fertilisers used were sulphate of ammonia, a nitrogenous fertiliser, and muriate of potash, a potassic fertiliser.

Planted on 22nd May, 1939. Seed—40 lb. per acre.
Germinated on 31st May, 1939. Variety—Gluyas Early.

Rate of Application of Fertiliser per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1933–39.*	Percentage Yields, 1933–39.*
	bus. lb.	%	bus. lb.	%
112 lb. Superphosphate ; 112 lb. Sulphate of Ammonia	14 46	96	12 9	98
112 lb. Superphosphate	15 22	100	12 26	100
112 lb. Superphosphate ; 112 lb. Sulphate of Ammonia ; 56 lb. Muriate of Potash	15 25	100	12 9	98

* Excluding 1936.

The average results over the six years this experiment has been conducted, show that there is no economic advantage to be gained from the addition of either a nitrogenous or a nitrogenous plus a potassic fertiliser to the usual dressing of superphosphate.

SEASONAL PLANTING EXPERIMENT.

The objects of this experiment are:—

(i) to ascertain the most suitable month to plant the mid-season, early and very early maturing varieties of wheat;

(ii) to determine the most prolific variety of each of the above types.

To meet the requirements of the experiment, the varieties were sown in three sections, viz.:—

(1) Planted in mid April, representing early planting.

(2) Planted in mid May, representing mid-season planting.

(3) Planted in mid June, representing late planting.

Planted on 15th April, 1939. Superphosphate—112 lb. per acre.
Germinated on 11th May, 1939. Seed—40 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
Bencubbin	18 14	115	113*
Gluyas Early	15 55	100	100
Dundee	14 37	92	92†

* Average, 6 years. † First year of trial.

Planted on 16th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 29th May, 1939. Seed—40 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
M 53	15 36	106	106*
Gluyas Early	14 42	100	100
M 51	16 30	112	112*

* First year of trial.

Planted on 16th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 29th May, 1939. Seed—40 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage, Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
Noongaar	17 33	113	89§
Gluyas Early	15 36	100	100
Geeralying	13 10	84	86‡
Bencubbin	17 20	120	112§
Gluyas Early	14 27	100	100
Dundee	12 26	86	86*
M 47	15 25	104	104*
Gluyas Early	14 51	100	100
Nabawa	13 44	92	98§
Bungulla	19 41	131	127†
Gluyas Early	15 2	100	100
Totadgin	15 17	101	103§
M 45	14 46	100	100*
Gluyas Early	14 43	100	100
Merredin	14 35	99	97§

* First year of trial. † Average, 2 years. ‡ Average, 6 years. § Average, 7 years.

Planted on 15th June, 1939. Superphosphate—112 lb. per acre.
Germinated on 26th June, 1939. Seed—40 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
Bencubbin	13 54	116	111‡
Gluyas Early	11 57	100	100
Bungulla	13 46	115	115†
Merredin	11 20	93	94‡
Gluyas Early	12 12	100	100
M 46	12 2	98	98*
M 47	13 18	107	107*
Gluyas Early	12 27	100	100
Noongaar	12 14	98	100‡

* First year of trial. † Average, 2 years. ‡ Average, 7 years.

"Bencubbin" continues to show its superiority in the April planting section, while in both the May and June planting sections "Bencubbin" and "Bungulla" are outstanding. Other good yielding varieties in the May section are "Gluyas Early" and "Totadgin," while "Noongaar" and "Gluyas Early" have yielded well when planted in the June section.

A feature of the experiment this year is the inclusion of a number of fixed crossbred wheats produced by the Department at its Merredin and Wongan Hills Research Stations. The results are for one year only, and therefore no definite conclusions can be drawn regarding them, but several show promise.

A Note on the Salt Tolerance of Wimmera Rye Grass (*Lolium rigidum var. subulatum*).

G. H. Burvill and L. J. H. Teakle,
Plant Nutrition Branch.

Throughout the wheat belt of Western Australia there occur on many farms, areas more or less severely affected by salt, so that their arable value for cereal crops is seriously impaired. On some farms the areas are quite small and confined to strips and patches along creeks, while on others in the lower rainfall areas, *e.g.* Salmon Gums district, the salt affected soil types may cover several hundred acres on a 1,000 acre block. Fortunately, such salt affected areas do not constitute more than a small proportion of the wheat belt as a whole.

Obviously, to make best use of such salt affected areas requires a search for, and investigation of, salt tolerant species of pasture and crop plants, and from experiments and observations in various districts, it has become recognised that Wimmera rye grass can be classed as a relatively salt tolerant plant. It is, moreover, a very palatable and useful pasture plant.

An interesting specific case of the salt tolerance of Wimmera rye grass has been recently furnished from East Katanning, where Mr. A. McD. Sargent has noted that on his property, "Boongadoo," this grass has been established for many years and grows well into several salt creeks. From such situations Mr. Sargent forwarded Wimmera rye grass plants, with the soil in which they were growing adhering to the roots, for a determination of the salt status of the soil. The samples were forwarded through Mr. J. H. R. Brown, Manager of the Bank of New South Wales, Katanning.

The Wimmera rye grass had seed heads up to 18 inches high and represented a very good growth of the plant. The specimens and soil were lifted on 3rd December, 1939.

An examination of the soil adhering to the plant roots showed:—

(a) on the surface a layer ½ to 1 inch thick, of grey to grey brown silty loam, obviously alluvial, over

(b) a variable layer of grey and grey brown sand and sandy loam to the depth of sampling, which was apparently 5 or 6 inches.

As the crowns of the plants were above the surface layer, it had apparently been deposited prior to this growing season. This surface layer contained some roots, but dense masses of roots were found in more sandy subsurface, particularly in one very sandy pocket. The whole of the soil forwarded is, no doubt, of recent alluvial origin.

For salt determinations two samples were taken from the surface layer of silty loam, and two from the more sandy subsurface. The results of the analyses were as follows:—

Salt in Soil growing Wimmera Rye Grass.

	Salt (sodium chloride) per cent. of dry soil.	
	(i)	(ii)
(a) Silty loam surface ½ to 1 inch thick	0.63	0.86
(b) Sand and Sandy loam subsurface 1 to 6 inches ..	0.25	0.65

Compared with normal soils, all these figures represent high concentrations of salt, in spite of which the grass has made excellent growth. No doubt, in the low-lying situation occupied by the plants there has been an ample supply of moisture throughout the growing season. It was noticeable, moreover, that the greatest concentration of roots was in the most sandy pockets where the salt concentration would most likely be lowest. Roots were common, however, even in the surface layer, where the salt figures are high, and the success of the grass in such generally saline situations is very encouraging.

On account of the variability in the concentration of salt in the soil adhering to the roots, it is not possible to draw precise conclusions regarding the salt tolerance of Wimmera rye grass, but the evidence indicates that satisfactory growth may be made where the soil salinity is considerably in excess of that tolerated by cereal crops.

In conclusion, attention is directed to the great value of vegetation cover in areas liable to soil salinity. The surface is protected from excessive evaporation with consequent accumulation of salt, and also from damage as a result of wind and water erosion which always occurs on bare unprotected areas. A salt tolerant plant such as Wimmera rye grass not only promotes soil reclamation, but also provides valuable stock feed, and hence some return for the capital invested in the land.

The Cost of Feeding Pure Bred Dairy Cows Under the Australian Official Pure Bred Herd Recording Scheme, Western Australia, 1938-39.

G. K. Baron-Hay, Superintendent of Dairying.

G. Slater, Recording Officer.

Since 1924 records have been compiled annually from figures obtained from the Pure Breeds Herd Recording Scheme to indicate, as far as can be accurately ascertained under practical conditions, the wide range of feeding costs amongst breeders in the hope that the information may assist in reducing the average cost of feeding by a judicious use of pasture, succulent conserved fodder, and wherever possible, home grown crops.

As the herds under test are spread over practically the whole area of the South-West and extend as far north as Geraldton and west to Doodlakine, it is to be expected that over such a wide range of climatic conditions there should be a considerable variation in the costs of producing milk and butter-fat. For this reason, the costs of various fodders which have to be purchased would vary from farm to farm, but, in order that a comparison may be made regarding the costs of production in the various herds, the average wholesale market price for any foods which may have to be purchased has been used.

It is not intended that these tables should be regarded in the nature of a competition, consequently owner's names have been replaced by a herd letter. Any breeder, however, may obtain the identification of his herd by applying to the Department of Agriculture.

Table 1 gives the prices of feeding stuffs which were adopted in calculating the various costs of feeding.

Table 1.

PRICES USED IN VALUATING THE FOODSTUFFS CONSUMED DURING THE YEAR ENDED 30th JUNE, 1939.

	£ s. d.
Chaff (per ton)	4 3 0
Wheat, crushed (per bushel)	0 3 0
Oats, crushed (per bushel)	0 2 6
Bran (per bushel)	0 1 2
Pollard (per bushel)	0 1 2
Silage (per ton)	0 10 0
Meggitts Meal (per ton)	16 0 0
Proteena (per ton)	12 5 0
Cowmeal (per ton)	15 0 0
Keymeal (per ton)	12 10 0
Meatmeal (per ton)	14 0 0
Brewer's Grains (per bushel)	0 0 5
Green Lucerne (per ton)	1 0 0
Green Maize, Sudan Grass, etc., and Cereal Crops—	
Chaffed (per ton)	0 15 0
Grazed (per head per week)	0 2 6
Meadow Hay (per ton)	3 0 0
Pasture (per head per week)—	
Good green	0 2 6
Dry	0 1 6

In Table 2 the average results which have been obtained during the past 16 years are set out.

Table 2.

PURE-BRED COWS UNDER OFFICIAL TEST—AVERAGE RESULTS OVER A PERIOD OF 16 YEARS.

Year ended 30th June.	Average Milk Yield per Cow.	Average Butter-fat per Cow.	Average Cost of Feed per Cow.	Average Cost of Feed to Produce 1 lb. Butter-fat.	Average Cost of Feed to Produce 1 gall. Milk.	Average Price, Butter-fat per lb.
	galls.	lbs.	£ s. d.	pence.	pence.	pence.
1924	600	319·50	10 4 10	7·70	4·09	19·5
1925	652	308·59	14 13 2	10·77	6·15	17·5
1926	624	312·01	14 14 7	11·15	5·66	19·0
1927	602	290·72	14 10 5	12·00	5·79	19·0
1928	592	280·56	15 11 4	13·34	6·34	19·5
1929	629	295·10	15 1 0	12·24	5·74	20·0
1930	636	294·98	14 10 3	12·74	5·10	19·5
1931	643	301·60	9 14 7	7·74	3·64	16·0
1932	696	318·96	10 18 3	8·21	3·76	14·0
1933	664	308·60	9 2 3	7·08	3·29	11·0
1934	720	333·70	10 2 6	7·28	3·37	10·0
1935	682	326·61	9 18 0	7·34	3·49	12·5
1936	681	320·14	8 14 7	6·54	3·08	12·5
1937	685	309·31	11 5 1	8·73	3·94	14·5
1938	664	306·99	10 19 7	8·58	3·97	15·0
1939	681	310·13	10 13 7	8·26	3·76	16·0

It will be noticed that the average production of butter-fat of all cows is slightly higher than for the previous year, and, as the average cost of feeding is slightly below that for the previous year, the cost of producing 1 lb. of butter-fat has been reduced from 8.58d. to 8.26d. per lb.

Owing to frequently occurring inquiries as to the value of different breeds for the production of milk and butter-fat, the average production and costs of the three breeds under test, namely, the Guernsey, Australian Illawarra Shorthorn, and Jersey, have been collated and compared in Table 3.

TABLE 3.

BREEDS COMPARED AS PRODUCERS OF MILK AND BUTTER-FAT.

Breed.	Average Milk per Cow during 9 months.	Average Test.	Average Butter-fat per Cow during 9 months.	Average Cost of Feed per Cow.	Average Cost of Feed to Produce 1 gall. Milk.	Average Cost of Feed to Produce 1 lb. Butter-fat.
	lb.	%	lb.	£ s. d.	pence.	pence.
A.I.S. (12 herds)	7,544	3·84	299·94	11 9 11	3·66	9·19
Guernsey (7 herds)	6,529	5·26	343·62	11 0 6	4·04	7·70
Jersey (13 herds)	5,781	5·34	308·58	9 1 8	3·77	6·74

The results during 1938-39 are similar to those in previous years, namely, that—from a consideration of the production of butter-fat alone—it would be expected that breeds with a higher average test would be economical producers of butter fat. Other factors, however, should be considered when endeavouring to compare the relative economy of breeds as dairy cattle, such as the extra quantity of milk which may be produced from the larger breeds, particularly the Australian Illawarra Shorthorn, which has a special value for feeding to pigs. Furthermore, the question as to whether or not the farmer is in a position to rear the steers or whether a suitable market exists for vealers must be taken into consideration. Should this be the case, undoubtedly the larger breeds have an advantage.

It is interesting to note that these expectations are borne out in Table 3, as, from the point of view of the production of butter-fat only, the Jersey breed leads followed by the Guernsey and Australian Illawarra Shorthorn. From the point of view of milk production alone, the Australian Illawarra Shorthorn leads, and, when the extra milk produced by this breed is considered, it would be unwise to draw comparisons as to the relative value of any one of these breeds for dairying purposes.

The following Table No. 4 indicates the relative cost of producing milk or butter-fat in dairying districts proper as compared with drier areas as along the Great Southern and the grain growing districts. As would be expected, the cost of production is considerably higher in the latter areas, butter-fat costing approximately 55 per cent more to produce in the dry areas than in the South-West.

TABLE 4.

COST IN LIGHT RAINFALL AREAS COMPARED WITH THE SOUTH-WEST.

Average.	Production.		Cost of Feed for—	
	Milk.	Butter-fat.	1 gal. Milk.	1 lb. Butter-fat.
	lb.	lb.	pence.	pence.
Dry Areas (15 herds)	6,934	298·84	4·38	10·16
Wet Areas (17 herds)	6,661	322·87	3·18	6·56

The following Table No. 5 places the various herds under test in order of merit as profitable butter-fat producers.

TABLE 5.

HERDS IN ORDER OF MERIT AS PROFITABLE BUTTER-FAT PRODUCERS.

Place.	Herd.	District (W = Wet D = Dry)	Breed.	Average Butter-fat per Cow for 9 months.	Available Skim Milk per Cow.	Value of Butter-fat at 1/4 lb.	Value of Skim Milk at 1d. gal.	Gross Return from Butter-fat and Skim Milk.	Cost of Feed per Cow for 9 months.	Profit per Cow.	Cost of Feed to Produce 1 lb. Butter-fat.
						£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	
1	AH	W	A.I.S.	358·09	6,450	23 17 5	2 13 9	26 11 2	6 5 0	20 6 2	4·19
2	E	W	Jersey	339·25	3,805	22 12 4	1 11 9	24 4 1	5 7 10	18 16 3	3·82
3	P	W	do.	346·80	4,558	23 2 5	1 18 0	25 0 5	6 11 9	18 8 8	4·56
4	AG	W	Guernsey	352·53	4,557	23 10 0	1 18 0	25 8 0	7 7 5	18 0 7	5·00
5	B	W	Jersey	354·99	4,139	23 13 4	1 14 6	25 7 10	9 3 4	16 4 6	6·20
6	U	W	Guernsey	328·86	4,157	21 18 5	1 14 10	23 13 3	7 15 2	15 18 1	5·66
7	Z	D	A.I.S.	356·90	6,024	23 15 10	2 10 2	26 6 0	10 11 9	15 14 3	7·12
8	Y	W	Jersey	332·51	3,805	22 3 4	1 11 9	23 15 1	8 4 0	15 11 1	5·91
9	I	D	do.	369·55	4,304	24 12 8	1 15 10	26 8 6	11 1 1	15 7 5	7·18
10	S	W	do.	321·59	3,460	21 8 9	1 8 10	22 17 7	7 19 8	14 17 11	5·97
11	D	W	Guernsey	346·80	4,075	23 2 5	1 14 0	24 16 5	10 0 0	14 16 5	6·92
12	AC	W	A.I.S.	330·79	6,114	22 1 0	2 10 11	24 11 11	7 0 10	14 11 1	5·14
13	O	W	do.	332·88	6,336	22 3 10	2 12 10	24 16 8	7 17 9	13 18 11	5·71
14	G	D	do.	359·45	6,204	23 19 4	2 11 8	26 11 0	13 6 0	13 5 0	8·88
15	M	D	Guernsey	394·58	4,885	26 6 1	2 0 9	28 6 10	15 8 8	12 18 2	9·39
16	H	W	Jersey	298·30	2,978	19 17 9	1 4 10	21 2 7	8 9 1	12 13 6	6·80
17	R	W	Guernsey	329·60	4,132	21 19 5	1 14 5	23 13 10	11 15 7	11 18 3	8·58
18	AD	D	A.I.S.	290·84	4,895	19 7 9	2 0 10	21 8 7	10 10 3	10 18 4	8·73
19	K	D	Jersey	206·93	2,674	13 15 11	1 2 3	14 18 2	4 0 0	10 18 2	4·64
20	AB	D	A.I.S.	321·94	5,059	21 9 3	2 2 2	23 11 5	12 16 4	10 15 1	9·55
21	L	D	Jersey	337·25	3,395	22 9 8	1 8 0	23 17 8	13 8 6	10 9 2	9·57
22	AF	W	do.	278·28	3,502	18 11 0	1 9 2	20 0 2	9 19 5	10 0 9	8·60
23	J	D	do.	300·30	3,535	20 0 5	1 9 6	21 0 11	11 15 5	9 14 6	9·41
24	W	W	do.	250·25	2,532	16 13 8	1 1 1	17 14 9	8 12 5	9 2 4	8·28
25	F	D	A.I.S.	318·50	5,216	21 4 8	2 3 6	23 8 2	15 19 0	7 9 2	12·01
26	AA	D	do.	256·26	4,042	17 1 8	1 13 8	18 15 4	11 10 10	7 4 6	10·82
27	N	D	Guernsey	301·76	3,755	20 2 4	1 11 4	21 13 8	14 9 5	7 4 3	11·51
28	AE	W	do.	287·20	2,994	19 2 11	1 4 11	20 7 10	13 5 0	7 2 10	11·08
29	V	D	A.I.S.	237·60	3,386	15 16 9	1 8 3	17 5 0	12 13 10	4 11 2	12·82
30	X	D	do.	264·4	3,871	17 12 7	1 12 3	19 4 0	14 16 8	4 8 2	13·48
31	T	W	Jersey	257·44	2,175	17 3 3	0 18 2	18 1 5	14 6 10	3 14 7	13·38
32	Q	D	A.I.S.	270·54	4,051	18 0 8	1 13 9	19 14 5	16 10 6	3 3 11	14·22
			Average	310·13	4,389	20 13 5	1 16 7	22 10 0	10 13 7	11 16 5	8·26

Available Skim Milk = (Total Milk — 60 gals. — 10%) — 120 gals.

It will be noticed that the average cost of producing 1 lb. of butter-fat is 8.26d. However, 8 of the 32 herds exceeded 12d. per lb. for the cost of feed to produce 1 lb. of butter-fat and may be regarded as definitely uneconomical herds. The reasons for this are that the majority of these herds were concerned not so much with the production of butter-fat at the ruling rate as with the production of whole milk at whole milk rates, the return from which is approximately double that for butter-fat production, and in consequence reliance in some instances is placed on purchasing fodders rather than on providing these by farming. If these 8 herds were to be excluded, the average production would be approximately 7.04d. per lb. of butter-fat.

The leading herd owned by Messrs. Dunkley Bros., Capel, showed a net profit of £20 6s. 2d., per cow over cost of feed. It will be noted that the cost of producing 1 lb. of butter-fat in this herd is greater than that of the Jersey herd owned by Mr. R. H. Rose, Burekup, occupying second place. The greater return per cow in the case of Messrs. Dunkley Bros.' herd, however, has been due to two factors, namely, the greater value of the skim milk for feeding to pigs and that, by the judicious use of concentrates, the average production of butter-fat was raised yielding a greater profit per cow. Mr. R. H. Rose bred very little concentrates during the year, and, if concentrates had been fed judiciously, there is little doubt that the average production of the herd would have been raised and a greater net profit per cow would have resulted, because, under the conditions of pasturage, some of the highest producing cows would have had difficulty in obtaining all their requirements from this source alone.

As one might expect from the results shown in Table 3, the first six herds in order of merit as butter-fat producers consist of five herds of the Jersey or Guernsey breed, although the leading herd is an Australian Illawarra Shorthorn.

The Table also indicates that the low cost of feeding of a herd does not necessarily mean that the net return from the production is an economical one. This is shown by a comparison of the profit per cow in herd "W" occupying 24th place where the cost of feeding was £8 12s. 5d., the profit per cow being £9 2s. 4d., and another herd, "B," of a similar breed where the cost of feeding was £9 3s. 4d. but the profit per cow £16 4s. 6d. It is extremely doubtful if the cows in herd "W," which averaged only 250 lbs. butter-fat were receiving a ration which would enable them to produce to their maximum capacity, and it is probable that any expenditure on concentrates for these cows would have resulted in an increased butter-fat production, as obviously maintenance requirements already were being supplied.

A study of the Table will disclose similar comparisons between other herds, and in order to determine whether or not the purchase of concentrates is profitable, it is necessary that a Breeder should know the capacity of cows for production and whether sufficient nutrients are being supplied for the cows to produce this yield.

In Table 6 the same herds are arranged in order of merit as profitable milk producers.

It will be noticed that the same herd owned by Messrs. Dunkley Bros., Capel, the cost of feed for which is extremely low as very little concentrates are purchased, is again the most profitable herd from the point of view of milk production, the profit over cost of feeding being £39 5s. 0d. per cow. Here again, the first six herds for milk production conform to what might be expected from a study of Table 3, namely—that five of these herds are of the Australian Illawarra

Shorthorn breed. The figure of 3.76d. per gallon for the average cost of feed is a valuable one and is in close approximation to that obtained during the previous years for which the results have been available.

Table 6.

HERDS IN ORDER OF MERIT AS PROFITABLE MILK PRODUCERS.

Place.	Herd.	Breed.	Average Milk per cow for 9 months.	Value of Whole Milk at 1/- per gal.	Cost of Feed per Cow for 9 months.	Profit per Cow.	Cost of Feed to Produce 1 gal. Milk.
				£ s. d.	£ s. d.	£ s. d.	pence.
1	AH	A.I.S. ...	9,100	45 10 0	6 5 0	39 5 0	1·65
2	O	do. ...	8,973	44 17 0	7 17 9	36 19 3	2·11
3	AC	do. ...	8,727	43 13 0	7 0 10	36 12 2	1·94
4	Z	do. ...	8,627	43 3 0	10 11 9	32 11 3	2·94
5	G	do. ...	8,827	44 3 0	13 6 0	30 17 0	3·62
6	P	Jersey ...	6,998	35 0 0	6 11 9	28 8 3	2·26
7	AG	Guernsey ...	6,997	35 0 0	7 7 5	27 12 7	2·53
8	AD	A.I.S. ...	7,372	36 17 0	10 10 3	26 6 9	3·42
9	E	Jersey ...	6,161	30 16 0	5 7 10	25 8 2	2·10
10	U	Guernsey ...	6,552	32 15 0	7 15 2	24 19 10	2·84
11	AB	A.I.S. ...	7,554	37 15 0	12 16 4	24 18 8	4·07
12	B	Jersey ...	6,532	32 13 0	9 3 4	23 9 8	3·37
13	Y	do. ...	6,161	30 16 0	8 4 0	22 12 0	3·19
14	I	do. ...	6,716	33 12 0	11 1 1	22 10 11	3·95
15	D	Guernsey ...	6,461	32 6 0	10 0 0	22 6 0	3·71
16	F	A.I.S. ...	7,507	37 11 0	15 19 0	21 12 0	5·10
17	S	Jersey ...	5,778	28 18 0	7 19 8	20 19 4	3·35
18	R	Guernsey ...	6,525	32 12 6	11 15 7	20 16 11	4·33
19	AA	A.I.S. ...	6,425	32 2 6	11 10 10	20 11 8	4·31
20	K	Jersey ...	4,905	24 10 6	4 0 0	20 10 6	1·96
21	AF	do. ...	5,824	29 2 0	9 19 5	19 2 7	4·11
22	H	do. ...	5,242	26 4 0	8 9 1	17 14 11	3·87
23	J	do. ...	5,861	29 6 0	11 15 5	17 10 7	4·82
24	N	Guernsey ...	6,106	30 11 0	14 9 5	16 1 7	5·69
25	X	A.I.S. ...	6,234	31 3 0	14 16 8	16 6 4	5·71
26	V	do. ...	5,696	28 10 0	12 13 10	15 16 2	5·35
27	Q	do. ...	6,434	32 3 0	16 10 6	15 12 6	5·98
28	W	Jersey ...	4,747	23 7 0	8 12 5	14 14 7	4·36
29	L	do. ...	5,706	28 11 0	14 8 6	14 2 6	6·07
30	AE	Guernsey ...	5,260	26 6 0	13 5 0	13 1 0	6·04
31	M	do. ...	7,361	36 16 0	15 8 8	11 7 4	5·03
32	T	Jersey ...	4,350	21 15 0	14 6 10	7 8 2	7·91
	Average		6,810	34 1 0	10 13 7	23 7 5	3·76

Coast Disease in Western Australia.

H. W. Bennetts, Veterinary Pathologist.

Coast disease of sheep in South Australia has been shown recently, by Marston et. al. (1938), to be due to a dual deficiency of copper and cobalt.

The purpose of this article is to give a brief description of investigational work which has demonstrated that an identical disease occurs in Western Australia, and to make recommendations for its control in this State.

From almost the earliest days of settlement it has been known that sheep and cattle could not be run continuously on much of the coastal country, because they developed coast disease, and the general practice has been to graze the coastal country during the autumn and early winter months with stock which have been depastured further inland on "sound" country during the rest of the year.

Although the coastal diseases described in both States have a striking resemblance and the affected country is in both cases of similar geological origin and type, information collected over several years appeared to indicate that there might be differences and suggested the possible presence of complicating factors in Western Australia. It is not proposed to discuss these here, but it did appear imperative, if working on assumption was to be avoided, to have more accurate and detailed information about coast disease in sheep in this State for comparison with the disease of South Australia, before control measures could be recommended.

This view was endorsed by Mr. I. W. McDonald, at that time one of the officers of the Council for Scientific and Industrial Research connected with the South Australian investigation, when he visited Western Australia at the end of 1937.

Since that time the writer has been in close touch with South Australian work and in 1937 spent several days at Robe where every opportunity was given for observing the experimental work being carried out on the property of Mr. R. Dawson. Later in the year Mr. Dawson himself came over here on a visit. Both Mr. McDonald and Mr. Dawson had an opportunity of seeing affected coast country, notably that west of Gingin where experimental work to be described was carried out.

1. THE IDENTITY OF COAST DISEASE OF SHEEP IN WESTERN AUSTRALIA AND SOUTH AUSTRALIA.

As the disease has been so thoroughly studied in South Australia, no systematic investigation was planned or carried out here. The purport of the following experiments and observations was merely to establish the identity of the disease in Western Australia.

(i) *An Experiment on the West Coast.*

In order that the course, symptoms, and pathology of the disease could be studied, arrangements were made to depasture experimental sheep on "Woolca Woolca," a property situate some 70 miles north-west of Gingin. The country is of the typical sand dune type formed from wind blown shell and is known to be "coasty." It is used for grazing cattle during the autumn and early winter months. Sheep have not been carried there for many years but it was reported that sheep would not survive more than several weeks on it.

Thirty acres of typical country, carrying shrubs and perennial grasses, were sheep-fenced and from 22nd May, 1938, seven mated merino ewes from Meckering (Wheat Belt) were depastured thereon. All ewes lambed within a few days of arrival. The flock was maintained there until the completion of the experiment on 10th August, 1939. From 30th July, 1938, nine visits were made at rather irregular intervals, observations recorded, and blood samples collected for haemoglobin and copper determinations.

Both ewes and lambs did very well for about four months. By 20th November, 1938, viz., six months after the commencement of the experiment, all lambs were showing signs of coast disease which developed typically. One died from mis-

adventure, four were killed for postmortem examination when badly affected (two on 20/11/38; one on 22/12/38, and one on 25/1/39) and two were cured and maintained on a copper and cobalt supplement (vide later) being healthy and in good condition at the completion of the experiment eight months later.

The ewes showed no signs of coast disease until they had been on the coast for nine months. The disease then developed typically. Three definitely affected ewes were killed for pathological examination (two on 1/4/39, and one on 10/8/39), one which broke through the fence and was off "Woolca Woolca" for two months during 1939 showed early signs of coast disease at the conclusion of the experiment, and two purposely left until they showed very advanced signs of coast disease were cured and maintained on a copper and cobalt supplement administered from 30/4/39 and 25/5/39 respectively. One ewe died of fly strike in September, 1938.

At the conclusion of the experiment nearly fifteen months after its inception, of the original flock of seven ewes and lambs only two lambs and three ewes remained, and with the exception of one of these ewes, which had strayed for a period on to sound country, all survivors were coasty animals which had been cured and carried through in a healthy state on copper-cobalt supplement. The supplement was administered as a drench twice weekly, the amounts being equivalent to a daily intake of 10 mg. Cu and 1 mg of Co.

The experiment with lambs was particularly significant, as critical experimental conditions were satisfied. Details are given:—

Four lambs which showed a similar early degree of coast disease on 20/11/38 were paired (on haemoglobin figures) and randomised into two groups, one to receive treatment and the other to act as controls. The experiment was commenced on 2/12/38 and was terminated on 10/8/39. Results are tabulated:—

Test Group.		Controls.	
Copper and cobalt supplement as a drench twice weekly.		No treatment.	
Lamb No.	Result.	Lamb No.	Result.
4	Fat, 25th January, 1939. Fat and well-grown at conclusion of experiment on 10th August, 1939 (Haemoglobin: 20th November, 1938 = 9·3 25th January, 1939 = 14·6 10th August, 1939 = 13·0)	3	Progressive coast disease. Killed for examination on 22nd December, 1938 in advanced stage of the disease (Haemoglobin: 20th November, 1938 = 9·3)
7	Good condition, 25th January, 1939. Fat and well-grown at conclusion of experiment on 10th August, 1939 (Haemoglobin: 20th November, 1938 = 9·6 25th January, 1939 = 17·6 10th August, 1939 = 11·5)	6	Progressive coast disease. Killed for examination on 25th January, 1939, in advanced stage of the disease (Haemoglobin: 20th November, 1938 = 10·2 25th January, 1939 = 5·7 R.B.C. = 5·3)

Note.—Haemoglobin = grammes per cent. determined by the Newcomer method, the apparatus being standardised gasometrically.

(ii) *Observations and Tests on the West and South Coasts.*

(a) *Examinations of naturally occurring cases of coast disease.*

A number of cases of coast disease were examined on a property ("Doubtful Island Bay") on the south coast. Blood samples were obtained from seven badly affected sheep and one of the worst was killed for pathological examination. All animals examined were anaemic (haemoglobin figures = 7.2, 5.1, 7.2, 7.8, 6.8, 7.6, 8.8).

A stray coasty heifer was examined clinically at "Woolca Woolca." Blood determinations were also made with the following results:—Haemoglobin, 6.2; red cell count, 3.5 million; blood copper 0.03 p.p.m.

(b) *Tests with copper and cobalt supplements.*

During 1938 and 1939, 350-400 cattle depastured on "Woolca Woolca" from March to June-July were given a copper-cobalt supplement in the drinking water while on the coast. The dosage aimed at was about 50 mg. Cu and 1 mg. Co daily. In both years, and particularly during the latter season when the supplement was administered throughout the whole period, the owners are definite from their observations that considerable benefit accrued. The cattle came off the coast in much better health and condition than previously. No trouble was experienced in droving mobs inland (70 miles) as no animals showed any evidence of coastiness. This is in contradistinction to past experience.

During 1938 a test was carried out on the Doubtful Island Bay property, the purpose of which was to ascertain whether it would be possible by means of a copper-cobalt supplement to retain sheep indefinitely there instead of shifting them to sound country after four months, that being the customary practice to avoid coast disease.

A preliminary trial in which a salt lick containing copper and cobalt was supplied to 200 merino wethers, was not an unqualified success. The sheep took lick fairly readily when confined but could not be encouraged to consume adequate quantities under the large paddock conditions obtaining. The results, however, were distinctly encouraging, but in view of practical difficulties in the way of providing supplement in a lick or in drinking water the owner desired to try drenching. The successful control of the disease by means of a drench given at two-monthly intervals on Thistle Island* has been reported (Scott 1938). This method of infrequent drenching was initiated on a large scale at Doubtful Island Bay. Results with some 2,400 merino wethers indicate that periodical drenching, preferably at monthly intervals (Cu 75 mg. Co 20 mg.) will control the disease *on this property* and that sheep so treated can be maintained there in good condition and that they will grow good fleeces. The observations are being continued.

The results of the experiments and observations briefly described above clearly indicate that coast disease of sheep in this State is indentical with that described in South Australia. The course, symptoms and pathology of the disease were as described. Owing to the inaccessibility of both properties on which observations were made, it was not practicable to carry out very detailed haematological investigations (blood examinations) but findings (haemoglobin results, blood smears and some red cell counts) were consistent with those of coast disease in South Australia.

*The disease there, however, is known to be due to an uncomplicated cobalt deficiency.

It was further shown experimentally that sheep badly affected with coast disease rapidly recovered (as when changed to "sound" country) and could be maintained in good health and condition with regular copper and cobalt administrations; it would appear also that the disease may be prevented by copper and cobalt given at much less frequent intervals.

A number of blood copper determinations, notably on sheep at "Woolca Woolca," were carried out by Mr. A. B. Beck, Assistant Animal Nutrition Officer. Low figures, 0.01-0.04 mg. per cent., were repeatedly observed in affected sheep. Animals treated with copper and cobalt, however, showed "normal" figures, 0.07-0.10 mg. per cent.

With regard to coast disease in cattle, although not yet experimentally proved, there is no reasonable doubt that the cause is identical with that of coast disease of sheep. Our own observations have been rather limited but much reliable information is available (notably from W.R.W. from "Woolca Woolca"). The usual symptoms are very similar to those of sheep. Observations indicate that cobalt and copper supplements are beneficial to cattle depastured even for relatively short periods on "coasty" country. Moreover, as is well known in this State, cattle are susceptible to single deficiencies in cobalt (Denmark Wasting Disease) and copper.

2. A DESCRIPTION OF COAST DISEASE.

For the benefit of those who are not familiar with the disease a brief description appears warranted.

(i) *Type of Country, Distribution and Importance of the Disease.*

So far as we are aware the disease is confined to coastal country derived largely from wind borne shell fragments. These form, typically, a fine sandy soil very rich in lime which in older formations may consolidate into limestone.

It has not been practicable to carry out any survey of affected country—observations have been confined to small areas on the west and south coasts, notably on the west coast west of Gingin, around Rockingham, Safety Bay and Mandurah, and further south between Bunbury and Busselton; on the south coast in the vicinity of Bremer Bay and Doubtful Island Bay.

It is known, however, that large areas of the type of country referred to occur along both coasts, these areas extending in places (e.g. "Woolca Woolca") for up to 11 miles inland. The boundary between "coasty" and healthy country is not always clear cut. Further, it has been found of recent years in this State, that large areas of heavily timbered country of totally different character and extending up to 20 miles inland from the coast, are deficient in copper or cobalt. It would appear probable that stock changed from these areas to the coast would develop coast disease more rapidly than stock coming from really "sound" country and thus carrying in their organs sufficient stores of these elements to maintain health for a period. This line of reasoning would explain the rapid development of coast disease in sheep reported from several "coasty" properties and its unexpectedly slow development in experimental sheep at "Woolca Woolca."

A survey of the South-West to determine what areas are affected with deficiencies of copper or cobalt or of both is projected.

In the meantime it may be safely assumed that coastal country derived from wind blown shell on which stock show typical signs of coast disease is affected with a dual deficiency of copper and cobalt.

"Coasty" country has up to the present been used almost exclusively as change country and generally does not carry stock during the winter months when the best feed is available. The solution of the problem of coast disease should make possible a more economic use of large tracts of valuable country in an assured rainfall area.

(*iii*) *Symptoms.*

Sheep generally do well for about four months on "coasty" country. Subsequently a malady slowly and progressively develops. This is characterised by depression, wasting and weakness. The eyes are dull and frequently show signs of discharge, the wool appears "dead" and in the late stages there is a marked break near the skin. The affected animal becomes progressively poorer and weaker, and is obviously anaemic, the skin, mouth and membranes of the eye being pale, finally almost white.

Ataxia, due to copper deficiency, may occur in the progeny of ewes depastured prior to lambing on "coasty" country.

Cattle. The usual course and symptoms of the disease are similar to those of sheep. The following description by W.R.W. can hardly be bettered:—

"The cattle become sluggish and lazy; the eyes become sunken and dull; the ears slightly drooped and also the head. The belly soon begins to draw in, the dung is very soft but not actually scoured. In a few cases I have noticed a substance like clotted milk passed in the urine; urine red. Pass dung in small quantities. Cattle showing these symptoms generally will travel up to 12 miles or so in a day; bad cases perhaps only four or five; but only when travelled slowly. If put to sudden exertion or forced to travel quickly they are likely to drop dead. Often very "coasty" cattle, when travelling even slowly, will stop and appear to shiver, which is a sign that if they travel any further they will lie down and die. Cattle that are affected with gradual wasting will be practically free from the effects of coastiness in a few days when shifted off the coast country to further inland, especially if brought on to clay country and clay water (or surface water on clay country)."

In addition to the above, very sudden deaths in cattle, notably of good conditioned cows heavy in calf, have been reported from "Woolca Woolca" and some other "coasty" properties. It would appear very probable that these are actually cases of "falling disease" which commonly occurs in inland copper-deficient areas in the Busselton and Northcliffe districts. Bennetts & Hall (1938). There has been no opportunity of verifying this by pathological examination. A transient red water of cows also is not uncommon in these areas.

Horses are generally said to do well on "coasty" country except that they may develop a condition known locally as "chip chip" which apparently takes the form of an excoriation of the skin of the legs. No cases of this condition have been investigated.

(*iii*) *Post-mortem Appearances.*

Sheep. The appearances are those of a starved animal—the carcase is wasted, skeleton light and fragile, and the liver is fatty. On microscopic examination the liver, and, to a less extent, kidneys, show marked fatty changes. Iron deposits (haemosiderin) are found in spleen, liver and kidneys. In our cases, contrary to South Australian findings, haemosiderin was more constant and abundant in the former than in liver and kidneys.

3. RECOMMENDATIONS FOR CONTROL.

The use of copper and cobalt supplement for the control of coast disease may be definitely recommended. The following particulars of dosage and methods of administration are those which have been suggested in response to departmental inquiries and which have given satisfactory results.

The quantities of copper recommended previously, however, are now reduced to conform with those advocated as a result of experimental work, carried out by the Council for Scientific and Industrial Research in South Australia. This has shown that the lower amounts of copper are adequate on the most seriously affected country. The proportion now recommended is five parts of copper sulphate to one part of cobalt chloride.

(a) *Lick.*

The following formula is suggested:—

Copper sulphate (bluestone)	10oz.
Cobalt chloride	2oz.
Common salt	1cwt.

Consumption at the rate of 1oz. per week per sheep and 8oz. for cattle would give an adequate copper and cobalt supplement. These doses should not be greatly exceeded and the amount consumed must be carefully checked by putting out small weighed out quantities. If consumption is excessive, the lick should be diluted proportionately with common salt.

For mixing, the copper and cobalt salts should be dissolved in ½ gallon of water (using a non-metal or unchipped enamel container) and thoroughly incorporated with the common salt until the colour is uniform throughout. A fine grained salt is best and lick troughs should be protected from the weather.

The South Australian work has demonstrated that the consumption of small amounts of copper and cobalt at short intervals give the best results and lick would provide the most effective and economical means of administration.

(b) *Drenching.*

To obtain the best results this should be carried out at frequent intervals. The solution recommended for compounding the lick may be used for the purpose. For use, for drenching, dilute one part of this solution with seventeen parts of water; half a pint added to 8½ pints of water would make a convenient quantity. The dose of the *diluted* solution is half a fluid ounce (15 c.c.), given once a week.

This method would be valuable for the treatment of small numbers, such as a small proportion of the flock not taking lick, as evidenced by absence of response, but would obviously be impracticable as a general measure of control. Under some conditions a compromise may be necessary and less frequent drenching prove a service. It should be remembered that the degree of "coastiness" varies from property to property, and the reported success of infrequent drenching on the "Doubtful Island Bay" property does not necessarily mean that such a method would be successful generally.

The following is the drench actually used on that property:—*

Copper sulphate	½lb.
Cobalt chloride	1oz.
Water	5gall.

Dose — 1 fluid ounce once a month.

*(c) *Drinking water.*

The following concentration has been suggested for drinking water:—

Dissolve copper sulphate	10oz.
Dissolve cobalt chloride	5oz.
In water	1gall.

Add half-pint of the solution to 400 gallons of drinking water.

The consumption by sheep of about 1 gallon and by cattle of about 10 gallons per day would give an adequate supplement. This might be a useful method of administration for sheep during the summer months and throughout the year for cattle.

(d) *Top dressing.*

Where improved pastures have been established on "coasty" country (e.g., on drained swamp country west of Capel), top dressing with copper and cobalt would probably prove the ideal method of controlling the disease. Pending further work, however, no definite recommendations can be made.

4. SUMMARY.

It has been demonstrated that coast disease of sheep in this State is identical with that investigated in South Australia where it was found to be due to a dual deficiency of copper and cobalt.

In this State affected sheep under experimental conditions have been cured and maintained on the coast in good condition by means of regular copper and cobalt supplementation. Indications are that coast disease of sheep and cattle can be controlled under field conditions.

The use of copper and cobalt supplements for the control of coast disease sheep and cattle in Western Australia can be confidently recommended.

5. ACKNOWLEDGMENT.

The writer desires to express his thanks to Messrs. F. A. and W. R. Wedge ("Woolca Woolca") and Messrs. E. A. and A. Y. Hassell ("Doubtful Island Bay") for their co-operation and assistance.

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*It will be noted that the quantities of copper sulphate have not been modified in this instance, the proportion of copper sulphate to cobalt chloride being 8-1 as originally suggested.

Potato Industry—Survey.

Summary of Report by Dr. J. G. Bald submitted to the Australian Council of Agriculture, Standing Committee on Agriculture, Hobart, February, 1940.

In August 1937 the Australian Agricultural Council considered representations for a grant to be made by the Commonwealth to the Potato Industry for research purposes. A Committee was appointed which collated information from each State and interviewed many of those interested in the industry. A comprehensive report has been prepared by Dr. Bald of this Committee, a summary of which report is given hereunder:—

1. *Climate of Potato-growing Areas.*—The conditions best suited to potato-growing are a temperate climate with a uniform supply of moisture during the growing period and absence of severe frosts. Potatoes are grown also in sub-tropical climates, but in the *cooler* part of the year. The times of planting and harvesting are so limited by weather conditions that potatoes must remain a seasonal crop, the bulk of production coming on the market within a few months.

The marginal rainfall limit throughout Eastern temperate Australia is generally between 25 and 30 inches, except when production takes place on swamps or swampy plains, or under irrigation. In Tasmania, the limits are slightly less than average, in Queensland slightly more.

Throughout Australia, the potato crop during the majority of seasons suffers from lack of moisture. Study of rainfall conditions in Tasmania for 25 years 1909-10 to 1933-34 showed that rainfall is one of the major determinants of yield. Although the Tasmanian rainfall is generally considered ample, the best yields were obtained when, during the three summer months, it was above average; however, if it was much more than 20 per cent. above average (4 years in 25), the yield was low.

This preliminary examination suggests that a thorough statistical study of climatic data, yields, etc., would be of value in forecasting production before crops are dug.

2. *Soil Types of the Potato-growing Areas.*—About 75 per cent. of the Australian potato crop is produced on basaltic soils. The next most important soil types are swampy and alluvial soils. The most important belt of alluvial soils on which potatoes are grown (Lockyer Valley, etc., Queensland) is, however, partly derived from basalt.

Overcropping has depleted the basalt soils of minerals and organic matter and has impaired their physical condition. Available minerals most noticeably lacking in many of the worn out soils are calcium and potassium. The loss of calcium increases soil acidity and renders the soils less capable of making mineral nutrients available to the plant. Addition of potassic manures does not compensate for the lack of potassium in the soil, as the added potassium is not retained in a form available to the plant.

Loss of organic matter and calcium leaves the basaltic soils too permeable; they cannot retain sufficient moisture between falls of rain for continuous growth of the potato plant.

Stoppage of the rapid loss of fertility and the economic replacement of lost organic matter and calcium are the first necessary steps in the regeneration of the basaltic soils. Regeneration cannot be accomplished without a revision of the types of agricultural rotations now practised (see under "Agricultural Practice").

The swamp soils present rather different problems. Few are so depleted of minerals and organic matter as the basaltic soils, because heavy manuring has been needed to make many of them productive. In Western Australia, some have been shown by the Department of Agriculture to be deficient in trace elements such as copper, manganese and cobalt.

The alluvial, like the basalt soils, have been severely exploited. Soils less well suited to potatoes than basalts and alluviums have not been overcropped to the same extent, because their initial fertility has not been great enough to allow extensive exploitation.

The manurial needs of potato soils have been broadly defined in most areas, but they need more intensive examination.

Additional surveys of potato soils are badly needed; north-western Tasmania is the only potato-growing area where the soils have been carefully and extensively examined.

3. *Agricultural Methods*—The bulk of the Australian potato crop is grown on the natural rainfall in association with crops less costly to produce and less demanding of soil fertility. Smaller proportions are irrigated (potatoes may be the only irrigated crop in the rotation) or are grown in association with vegetable crops.

Potatoes have been widely grown in alternation with cereals, as part of a purely agricultural rotation.

The fertility of potato soils has been depleted by both these types of crop, and only a fraction of the organic matter and plant foods lost from the soil has been replaced by manuring and the growing of pastures to carry stock. The rapid loss of soil fertility has been slowed down by alternation of potatoes and cereals with legumes, the ploughing in of green crops, manuring and an increase of stock-raising; but the cropping systems of most potato growers allow the loss to continue. In the long run the most serious problem facing potato-growers is how to adapt their methods to obtain profitable yields without causing any loss of soil fertility. In many instances they are faced, in addition, with an even more difficult problem—how at the same time to put back into the soil some part of what it has lost by overcropping.

It hardly needs saying, that the problem of lost fertility is not a problem merely of the potato-grower. It arises out of the system of exploiting the soil, which has been common to almost the whole farming community in this and other countries opened for cultivation during the last two or three centuries. It is the preliminary stage of the process which in drier areas leads to soil erosion.

The stoppage of depletion of potato soils needs a radical change of farming policy. The change is already being continually advocated by State Agricultural Departments, and is being made by progressive farmers. It involves an increase in productivity and a lessening of acreage of areas sown to potatoes each year, combined with a longer and less exhaustive rotation, adequate manuring, periodical sowing down to pastures, and the carrying of stock.

The principles of such a policy are well enough understood, although details for specific areas need to be studied. Such a policy could quite safely be put into practice over wide areas as quickly as the farmer could be persuaded to change his methods, and the market could absorb the produce of his farm.

A difficulty in the way of the change would be the inability of marginal producers to find capital for stock, improvements, extra equipment, etc. A related difficulty on small holdings would be the inability of the farmer to lengthen his rotation by reducing his acreage, without for a time reducing his net returns below a living wage. A large proportion of potato-growers, however, are in a position to improve their rotational practices.

The actual cultivation of potatoes is on the average much more efficient than the rotational practices. Great improvement on the methods of the more capable farmers is not to be expected. In the selection and care of seed and manuring there is need for improvement on a large proportion of holdings.

The supply of good seed grown under Certification Schemes is making it possible for more farmers to prevent losses from inferior seed stocks. The extension of Certification Schemes is continuing. However, even where they are well established insufficient use is made of certified seed.

Probably the majority of seed is sown without greening by exposure to light. The method of greening in trays or by other means should be widely extended.

Most potato-growers apply less than the optimum amounts of fertiliser, and there is a confusion of methods in its application. Local adaptations of findings on the best methods of applying fertilisers are necessary, as well as on the best amounts to apply. There is much information on methods of application obtained under American conditions, but there cultivation methods are adapted to machine planting.

Extension of the practice of irrigating potatoes, particularly in the Lockyer Valley, Queensland, raises serious problems of management. These need investigation.

In Australia, machinery is seldom used for planting and harvesting even on large holdings. Cultivation practices, spacing, hilling, etc., are adapted to sowing by hand and digging with the fork. Enquiry into the use of machinery and changes in practice that machinery would necessitate would be of value to growers who sow large areas to potatoes. Machinery has often been tested by farmers, but generally under conditions adapted to hand labour.

There is much available information on which improvements in agricultural practice could be based and, where it is not complete, investigation would consist mostly of finding local applications of established principles.

4.—*Diseases and Pests of Potatoes.*—The best estimate the committee has been able to make from the limited data available, of losses due to diseases and pests of potatoes in Australia, is that it approaches 20 per cent. of the total yield to be expected in their absence. This estimate excludes the effects of latent mosaic, due to a virus referred to below. In terms of acreage and production, such losses mean the virtual waste of 25,000 acres of each season's planting and of about 65,000 tons of the production.

(a) Diseases.

The diseases of most importance in Australia may be classified as follows:—

(i) *Virus Disease.—Preventible*: Mainly of three types transmitted in the field by aphides. They alone are estimated to reduce the total yield by 7½ per cent or more, which is equivalent to a total loss on about 10,000 acres or from 25,000 to 30,000 tons in yield. The viruses are carried over from season to season in the tubers.

Virus diseases can be controlled through Certification Schemes. (See later.)

Latent Mosaic: Is carried in almost every tuber of the principal varieties grown here. It causes very slight symptoms or none, but probably causes an overall reduction in yield which is unnoticed because virus-free stocks of the same variety are not available for comparison. Unless occasional virus-free tubers can be found, the only way of getting rid of the disease will be by ceasing to grow the varieties affected.

(ii) *Scab Disease,* of which *Rhizoctonia* scab is most important. The organisms causing these diseases are carried in the soil and on the surface of the tubers, and some affect the tops of the plants as well as the tubers.

In a large measure they can be controlled by proper rotational practices, "dipping" seed tubers in fungicidal solutions, etc.

(iii) *Wilt Diseases,* caused by fungi (*Fusarium, Verticillium,* etc.) and bacteria (blackleg, etc.) which inhabit the soil and are carried inside seed tubers. Their incidence can be reduced by good agricultural practices and selection of seed.

(iv) *Tuber Rots.*—Of these the principal is *Pythium de Baryanum* which is carried in the soil of infected fields in certain districts. It can be eliminated by a period of planting to grass or other non-susceptible crops. The organisms which cause the foliage diseases known as late and early blight also cause tuber rots.

(v) *Foliage Diseases.*—Late blight rarely occurs in epidemic form over large areas, except in northern New South Wales, Queensland and in isolated districts of other States. Early blight is more important because it is more widespread although not so catastrophic. Spraying with copper sulphate mixtures will control these diseases.

(b) Pests.

The Potato Moth is the most serious pest and causes considerable damage, particularly in hot climates and during hot, dry seasons. It attacks the tubers as well as the tops and can go through its life in stored potatoes.

It cannot be controlled by dusts or sprays because the grub lives inside the tissues of the plant and is protected from direct attack.

There is not sufficient information available as to the insect's life history and the multiplication of populations under Australian conditions to guide research into effective control measures.

Hence, field and laboratory studies on the Potato Moth would be of very considerable value; they are a necessary prelude to the discovery of means for reducing its depredations.

Other pests, which include cut worms, Rutherglen bug, thrips, etc., are much less serious than the Potato Moth, and for most of them efficient methods of control are known.

5. *Varieties of Potato Grown in Australia.*—In Australia there has been a natural selection of varieties resulting in the emergence of six, which now make up more than 90 per cent. of the acreage of potatoes. Three (Carman, Brownell and Delaware) originated in America, one (Up-to-date = Factor) in England, one (Bismarck) probably in Germany, and there is one (Snowflake) whose origin is unknown. Of these, Brownell and Delaware are wrongly named, their true names being Adirondack and (probably) Earliest of All.

Each of the main potato-growing regions has its characteristic varieties. These are summarised below:—

Victoria—South Australia: Carman, Snowflake, Up-to-Date.

Tasmania: Brownell, Bismarck.

New South Wales—Queensland: Factor (=Up-to-Date), Carman.

Western Australia: Delaware. (See note page 55.)

Of the six varieties, Carman, Brownell, and Bismarck are grown in spite of their susceptibility to virus diseases and other shortcomings because they produce good quality potatoes. The other three produce average or low quality tubers but they have special virtues, e.g., Snowflake, resistance to many diseases and to dry conditions.

Among valuable minor varieties is one more of American origin, Katahdin, which has been introduced to Australia recently and will probably be widely grown when stocks are multiplied.

Among varieties which have gone out of cultivation was one of outstanding merit, Brown's River or Circular Head. Sufficient material might still be found to establish stocks and test it again.

The suitability of American varieties to Australian climatic conditions is probably attributable to similarities between the American environment, where they were bred, and the Australian environment. However, none of the varieties grown here is ideally suited to its environment, and probably now or at some future time better varieties could be found to replace them.

At present the introduction and testing of new varieties is preformed haphazardly by State Agricultural Departments and private individuals. It could be done much more thoroughly by a centralised body whose function would be to introduce from abroad and test varieties with promising reputations. Such a body would need, as well as a field station and field laboratory in a potato-growing district, the close co-operation of the State Agricultural Departments. It would devolve on the latter to make final tests of suitability to particular districts and, if a variety were found suitable, to distribute it to farmers.

6. *Seed Certification Schemes.*—Certification Schemes are in operation in Tasmania, New South Wales, and Western Australia, and a scheme is being developed in Victoria. Their primary object is to protect potatoes against virus diseases, but they are also useful in maintaining the purity of varieties, in reducing the incidence of various fungal and bacterial diseases, and in sorting out vigorous and high yielding strains. All troubles which are wholly or in part tuber-borne, and are readily detected by inspection, are (or could be) reduced or eliminated under a Certification Scheme.

There are two steps in the production of certified seed: the maintenance of high quality foundation stocks, and the multiplication of seed stocks from them. Both are under the control of certification officers who inspect the growing crop and the tubers after they are dug, and provide official seals for bags of tubers that pass all inspections.

The actual maintenance of foundation stocks may, as in Tasmania, be performed by the Agricultural Department. It may be performed by growers. The multiplication of stocks is always performed by growers.

In the control of diseases, Certification must be supported by detailed information of the diseases concerned. This is particularly true of Virus Diseases.

Information as to the following is essential for the successful application of Certification Schemes to the elimination of Virus Diseases:—

(i) The types of virus which attack potatoes in the various localities.

(ii) The reactions of local varieties of potatoes to the different viruses.

(iii) The rate of transmission of viruses in the various localities.

(iv) Variation in the rate of transmission from year to year.

(v) Nature and habits of the agents which transmit the diseases.

(i) and (ii) are already being investigated by the Council for Scientific and Industrial Research in co-operation with State Agricultural Departments. There has been some work of a fragmentary nature on (iii) and there is a little information, but very little on (iv) and (v). As the rate of transmission depends on the number and effectiveness of the transmitting agents, a study of these agents (which are mainly aphides) is the next most important step in the control of virus disease in Australia. This should take the form of combined insect and virus disease surveys in the principal potato-growing districts.

Consideration should later be given to the possibility of eliminating or controlling the latent Mosaic type of virus.

7. *Potato Breeding.*—The discussion on varieties suggests the desirability of obtaining types adapted in the highest possible degree to the Australian environment. This is more likely to be accomplished by breeding than by introduction. Australia has not yet bred any outstanding varieties (unless the Snowflake, of which the origin is unknown, happens to be Australian), because there has been little concerted effort to do so. The only systematic breeding programme in operation is that conducted by the New South Wales Department of Agriculture.

Further breeding with ordinary commercial varieties appears unlikely to give substantially new types. Many of the best combinations of characters in the available genetic material already exist in established varieties. With the discovery by Russian botanists of many wild and cultivated varieties of potatoes in South America which contain comparatively enormous reservoirs of new and lost characters, an outlook of great promise has been opened to the potato breeder. Among the characters now available to him are:—

(i) Resistance to nearly all important virus diseases, to late blight, and to some other diseases and pests.

(ii) Resistance to drought.

(iii) Frost hardiness.

(iv) Very short or very long periods of tuber dormancy and exceedingly rapid maturity.

(v) Ability to produce maximum crops under short daylight conditions, i.e., during days when there is less than thirteen hours' full light. Most commercial varieties only produce their maximum yield under long daylight conditions.

(vi) Possibly greater yields than are at present obtainable and a wider range of tuber characteristics.

Any breeding programme with potatoes has to envisage continued effort for a period of at least 20 years, and the raising and testing of many thousands of seedlings. It involves:—

(a) The introduction, maintenance and testing of material for breeding.

(b) Study of the genetics of breeding material.

(c) The actual making of crosses and the raising of seedling types.

(d) The testing of these seedlings under various environmental conditions for their inherent characteristics.

Each of the four steps in breeding requires special forms of technical knowledge; and if breeding is to be done on a large scale, it needs a fairly wide range of equipment and personnel, and some division of function. For example, at a central station material might be kept and crosses made, and the seed from the crosses might be tested at a distant sub-station or even in another country. Provided the various centres are properly co-ordinated and directed, considerable advantages may be derived from a division of function, the principal one being the comparatively economical extension of the breeding programme to cover a wide range of characters. A programme of potato breeding for Australia is recommended for consideration. Two alternative policies might be considered:—

(i) A restricted and self-contained programme aiming at the solution of one or two problems of importance to Australia, e.g., the production of virus-resistant forms suited to local climatic conditions; or

(ii) One based on co-operation between Australia and the other parts of the British Empire, and covering a wider range of problems.

The former would require a personnel of one or two plant breeders and possibly another officer engaged in the introduction and testing of possible parent stocks, a permanent field station in a good potato-growing locality and co-operative arrangements with Commonwealth and State Departments for testing seedlings, etc.

The latter might mean the assumption of one or more of the functions set out under headings (a) to (d) above. A first step towards Empire-wide co-operation in potato breeding has been taken during the last two years in the support given by India and Australia to the recent small English expedition which collected potatoes in South America.

Note.—Of the varieties in the main potato-growing regions referred to on page 53, it should be mentioned that Carman in some districts is decreasing in acreage because of infection with virus diseases and the inferior Snowflake is taking its place. The relative proportions of the other varieties appear to be showing only season-to-season fluctuations.

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Black Spot or Scab of Apples.

SERIOUS NEW OUTBREAKS RECORDED IN THE ALBANY AND MANJIMUP DISTRICTS.

W. P. Cass-Smith, Plant Pathologist

Black Spot or Scab of apples, caused by the fungus *Venturia inaequalis* (Cke) Wint. or alternatively *Fusicladium dendriticum* (Wal) Fcl., has now been recorded from all States in the Commonwealth and it appears to be present to a greater or lesser degree in all countries where apples are grown.

Prior to 1930 the disease was unknown officially in Western Australia, but during that year the first authentic record of its appearance locally, was reported by Pittman (1) and further outbreaks were later reported by the same writer (2).

Wherever the disease occurs, it is regarded as a serious menace, for not only may the yield and quality of the crop be greatly reduced in seasons favourable for its development, but the costs incurred in applying control measures are also very considerable.

It is not to be wondered at, therefore, that many authorities consider it to be the most serious of all apple troubles, and all orchardists in this State who have, through no fault of their own, experienced its ravages, will completely agree with this opinion, as it applies here.

RECORDS OF THE DISEASE IN W.A. PRIOR TO THIS SEASON.

From April, 1930, until November, 1939, five outbreaks of the disease have occurred locally, and in only two cases can the outbreaks be attributed to infection which has spread from a common source, viz: —

Outbreak (1).—April 4th, 1930, on the property of Mr. J. W. Brearley of Manjimup, this being the first unquestionable record of the disease in W.A.

Outbreak (2).—April 29th, 1930, on Mr. Faulkner's property at the Porongorups (which is about 100 miles away from Manjimup).

Outbreak (3).—February 5th, 1936, at Manjimup, on a property situated some five miles away from Mr. Brearley's on which the first outbreak occurred.

Outbreak (4).—March 7th, 1936, at Mt. Barker on Mr. G. Enright's property, which is approximately 100 miles from Manjimup. (Also traces of the disease were discovered on 11th June, 1937).

Outbreak (5).—November 19th, 1937, at Manjimup on a property adjoining that in which the third outbreak occurred in 1936.

It is worthy of note that in each instance immediately the presence of the disease was suspected, the Department was notified at once, either by the grower concerned or by another person on his behalf.

This public spirited action, which was made in each case with a full knowledge of the necessary obligations it would for the time being incur, was greatly appreciated both by the Department and all others interested in the welfare of the Apple Industry, for as the outbreaks were all discovered at an early stage, it enabled prompt action to be taken with the object of completely eradicating the disease and preventing its spread to other properties.

As a result of this timely knowledge, and the rigorous measures which were at once put into operation,* no signs of the disease have been discovered for nine years on the orchards where the first and second outbreaks occurred, nor for three years at the Mt. Barker orchard.

There is thus full justification for the claim that these outbreaks have been eradicated.

It is disappointing to record that more difficulty has been experienced in attempting to eradicate outbreaks 3 and 5, for until recently it was believed that these also had been successfully dealt with.

Outbreak 3 as previously reported in this Journal (2) was discovered in February, 1936, by the grower concerned, near the centre of his 15-acre orchard, and altogether some 40 or 50 trees, distributed over an area of 1½ acres, were found to be affected.

Immediate action was taken, and following the spring spraying schedule applied that year, no further evidence of the disease was noticed in the orchard despite constant efforts to find it, until this season. On the 19th November, 1937, however, a telegram was received from an adjoining grower, advising that Black Spot had been found in his orchard, and after verifying this report, further measures were put into operation on both properties for its eradication.

During the 1938-39 season, very careful inspections were made at intervals, in both orchards, and as not a single trace of the disease was found, it was believed that these, in common with previous outbreaks, had been wiped out.

OUTBREAKS DURING THE 1939-40 SEASON.

Recurrence of the Disease at Manjimup.

It is now obvious that Black Spot in a very slight form must have escaped detection on these properties during these inspections, for on November 15th, 1939, aided by very favourable weather conditions, a recurrence of the disease was reported by one of the growers concerned to Horticultural Instructor A. Flintoff, and during inspections made by this officer, it was found on both properties. Although since the outbreak originated in 1936 the disease had apparently spread to the orchard adjoining, this was the first definite record of its occurrence on both orchards at the one time.

Accompanied by the Acting Superintendent of Horticulture, Mr. H. R. Powell, the writer visited the district, when it was found that on the orchard where the first outbreak occurred in 1936, the disease was fairly slight, and restricted to "Cleopatra" and "Granny Smith's" varieties, only a few trees being badly affected. It was also noted that the affected area was confined to a portion of the orchard some distance from the area originally affected.

On the adjoining property the disease had recurred in the same part of the orchard, but at this stage it was not very well developed and it was visible mainly on the leaves. With the exception of some 15 rows of trees near the northern boundary, however, the disease was very general throughout the particular 15-acre block, and here also it was confined to the varieties "Cleopatra" and "Granny Smith's."

*These measures were originally planned by Mr. G. L. Sutton, Mr. G. W. Wickens and Mr. H. A. Pittman, who formerly occupied the positions of Director of Agriculture, Superintendent of Horticulture, and Plant Pathologist, respectively, in this Department.

New Outbreaks at Kalgan River and Jardee.

Knowledge of new outbreaks shortly came to hand, for on January 15th, 1940, Horticultural Instructor A. J. Gulvin, while assessing the yield of growers' crops (as required by the Apple and Pear Acquisition Scheme), discovered in an orchard at Kalgan River, near Albany, apple leaves and fruits which he thought were affected with Black Spot. Specimens were at once submitted to the Plant Pathologist, who confirmed his diagnosis.

The discovery of a second outbreak was also due to the alertness of an assessor, Mr. C. H. Button. On January 19th this officer, during the course of his duties, discovered the disease in a small orchard at Jardee.

Both districts were promptly visited by the Acting Superintendent of Horticulture, Mr. H. R. Powell, and the writer, and thorough inspections of the affected areas were made.

At the Kalgan River outbreak the disease was particularly severe on some 7 or 8 rows of "Cleopatra" apple trees, and altogether an area of approximately 2 acres in a 10-acre orchard was affected.

When stripping of the very badly diseased trees of this variety was carried out, practically all the fruit and many leaves showed lesions of the fungus. The disease appeared to have been active since quite early in the season, for fruit attacked at all stages of growth were noticed, and many of the lesions on both fruit and leaves were covered with the typical greenish brown spores of the summer or *Fusicladium* stage.

A few trees of "Yates" and "Granny Smith's" varieties were also badly attacked (the former on the leaves only), while symptoms of the disease were also noted on both leaves and fruit of "Dunns," "Jonathan" and "Delicious" in various other portions of the orchard. As this is the first record in this State of either leaf or fruit infection on "Delicious," which under Western Australian conditions appears to be very resistant to the disease, the severity of the outbreak can be appreciated.

Prior to this visit Horticultural Instructor Gulvin had hurriedly inspected neighbouring orchards and discovered that the disease had spread across the Kalgan River to an orchard some 300 or 400 yards away in a southerly direction.

The disease could only be found, however, on two "Granny Smith's" trees in a four-acre orchard, and these were situated at approximately the nearest point to the main outbreak.

Another larger block of trees, belonging to the same grower but some distance away, were apparently unaffected. Another neighbouring orchard some 200 to 300 yards away, but in a north-easterly direction, was subsequently inspected and the writer concentrated his attention on a single "Dunns" tree at the nearest point to the main outbreak. Eventually, after searching for fully twenty minutes, a single leaf showing what appeared to be the very early stages of the disease, was discovered. The symptoms at this stage, however, were not sufficiently clear-cut for accurate diagnosis, but subsequently after keeping the leaf alive under conditions suitable for the development of the fungus, Black Spot was positively identified.

All other neighbouring orchards were similarly inspected, but no further spread of the disease could be discovered in this district.

On visiting Jardee, it was found that the new outbreak was confined to a small commercial orchard, surrounded by a dense belt of virgin bush and situated approximately two miles away, as the crow flies, from the Manjimup orchards where the disease recurred earlier this season.

Here, the affected area was restricted to several rows of trees of the "Cleopatra" and "Dougherty" varieties which were severely attacked, but a few "Granny Smith's" and "Sturmer" trees had also suffered considerably. It is impossible to state, with any certainty, how the disease originated within this orchard, for being surrounded by dense timber and separated by a distance of at least two miles from the orchards where a recurrence of the disease broke out earlier in the season (and between which no personal contacts had been made), it seems improbable that it was due to wind borne infection. Furthermore, in previous outbreaks which were discovered at an early stage, the spread of the disease has not yet been recorded beyond the boundaries of adjacent properties. In view of all the circumstances, it seems more likely that the outbreak was due to an infection centre within the orchard itself.

MEASURES EMPLOYED IN AN ATTEMPT TO ERADICATE THE DISEASE.

Measures which it is fervently hoped will lead to the complete eradication of all outbreaks were immediately put into operation, and it is pleasing to record that these, in all cases, are being carried out most conscientiously by all growers concerned, with the fullest assistance of officers of the Department.

The following rigorous measures, based on those which have been successfully used for the eradication of previous outbreaks (modifications only being necessary, according to the nature and extent of the outbreak, and the time of its occurrence), are being enforced in one affected orchard and they will serve to show how seriously the Department regard the present outbreaks.

(1) All trees in the infected area and the ground beneath were sprayed forthwith with home-made Bordeaux mixture 6 : 6 : 40 strength, plus spreader, and as an added safeguard against the spread of the disease, a buffer area around the infected trees was also sprayed with home-made Bordeaux mixture 3 : 5 : 50 strength, plus a spreader. (Calcium caseinate at the rate of 1 lb. : 50 gallons of spray is preferred, but flour at the rate of 1 lb. : 50 gallons or skim milk, 1 gallon : 50 gallons are also suitable. See Leaflet 314.)

(2) All visibly infected fruit and leaves were stripped and destroyed; after the fruit of each variety is gathered as it becomes mature, the trees of each variety throughout the whole orchard and the ground beneath must be sprayed with home-made Bordeaux mixture 6 : 6 : 50 strength, plus spreader.

No apples may be sent away from the orchard either for sale or gift, without first obtaining permission from an inspector, and then only to destinations approved by him.

(3) Early in April a quick-growing cover crop of either oats, rye, or barley must be shallowly sown throughout the whole orchard, so that the diseased leaves will be prevented from blowing after leaf fall onto still uninfected parts of the same orchard or to other healthy orchards.

In August or early September (but at least a fortnight before spur burst commences) the cover crop must be deeply ploughed under, in one direction only, and subsequent cultivation must be delayed until approved and then limited to very light harrowing.*

*The Black Spot fungus persists in the affected leaves from one season to the next and during the winter months it forms fruiting bodies known as *Perithecia*. About the time that "spur burst" commences in the spring, the fruiting bodies burst and fungal spores or seeds are ejected from them into the air with considerable force. If the spores alight on the young leaves, blossoms, or fruits, they germinate in moisture and again bring about the disease. In order to prevent the disease reoccurring during the spring, the leaves must be buried deeply just before "spur burst" and left undisturbed until they have completely rotted. Cross ploughing or deep cultivation, if done too early, will bring the leaves up to the surface before the rotting is complete and before the fungal seeds contained therein are harmlessly dispersed under the soil, allowing infection to occur.

All areas beneath the trees which cannot be reached by the plough must be dug under by hand, this work to be so arranged that it is completed by the time the ploughing is finished.

In spring all apple trees in the orchard must be sprayed according to the following schedule:—

1. At "spur burst" when the tips of the young leaves are showing, home-made Bordeaux mixture 5 : 4 : 50, plus spreader.
2. At the "pinking" stage of blossoming when the majority of blossoms were showing pink, but before the petals had opened out, home-made Bordeau mixture 3:4:50, plus spreader.
3. At the "petal fall" stage, home-made Bordeaux mixture 2:5:50, plus spreader.

To assist the unfortunate growers with the carrying out of this onerous work, especially the destruction of all visibly infected fruit and leaves, officers of the Department have been stationed in each district almost continuously since January. As a result of their co-operation with the growers concerned the infection has in each case been very materially reduced.

ORIGINATION OF THE DISEASE IN W.A.

From the time the disease was first recorded in this State in 1930, the question of the source of origin of the outbreaks was a matter for conjecture.

On a number of occasions the importation of young apple trees from the Eastern States of Australia, where Black Spot is prevalent, was regarded with suspicion, and referring to the third outbreak of the disease which occurred at Manjimup in 1936, Pittman (2) states:—

"It is difficult to be sure of the manner in which the disease was introduced into Western Australia in 1930, or in the case of the present outbreak. In the present instance the disease apparently originated in a "Yates" apple tree growing adjacent to a group of young apple trees now in their second year, so that it is possible that the disease was introduced on an apple leaf still attached to one of the young trees or mixed up with the soil around the roots.

"In view of the fact that the majority of the young apple trees for planting in Western Australian orchards have always been obtained from Victoria, in which State the disease has long been serious and widespread, it is rather surprising that the apple-growing industry of this State has for so long remained free of this disease, which is held by many authorities to be, perhaps, the most serious of all apple troubles."

Since that time, however, overwhelming proof has come to hand that these suspicions were well founded.

On May 26th, 1937, Horticultural Adviser Powell discovered the disease on the leaves of young apple trees imported from Victoria, and carried over in an Albany nursery from the previous season. All apple trees in the nursery were forthwith destroyed and all trees from that consignment which had been forwarded to growers during the preceding season were closely inspected, both then and subsequently, with the result that no outbreaks have originated from them.

During the winter of 1937, in view of this experience, a close watch was kept on all consignments of apple trees imported from the Eastern States, and in a number of these consignments leaves affected with Apple Scab were discovered.

In this particular instance heavy autumn rains had apparently occurred, causing renewed leaf growth and as the trees had not been stripped of leaves before despatch the disease was in many cases readily apparent.

All nurserymen in whose consignments infected trees had been detected at the Western Australian ports of entry were forthwith given the option of either having these consignments destroyed or returned; altogether more than 11,000 trees were thus affected.

In order to prevent a repetition of this occurrence, which if undiscovered might have seriously jeopardised the future welfare of our apple industry, all Eastern States Departments of Agriculture, and nurserymen, were subsequently notified by the former Superintendent of Horticulture, Mr. G. W. Wickens, as follows:—

"As you are aware a large number of young apple trees sent forward from the Eastern States to Western Australia last season were refused permission to be distributed to growers owing to the fact that they were infected with Apple Scab, *Fusicladium dendriticum*, and to prevent that disease, which, fortunately, is very rare in Western Australia, from gaining a hold in this State it has been decided that all apple trees imported into Western Australia will, in future, before leaving the department's hands be dipped in Bordeaux mixture.

"As pear trees are possible carriers of Pear Scab, *Venturia pyrina*, they also will be subject to dipping upon arrival.

"The dipping in Bordeaux mixture will take place as a measure of safety, but should any trees be found infected with Scab, the supplying nurserymen will be given the option of having them destroyed, or returned to them. As the disease was last year found in every instance on the leaves of the trees, it is essential that all leaves should be removed before the trees leave the nursery."

It is not anticipated, therefore, that further outbreaks will originate from apple trees imported during and after the winter of 1937.

CLIMATIC CONDITIONS AND THE DEVELOPMENT OF THE DISEASE.

The development of the disease is favoured by fairly cool, moist weather during the growing season, and these conditions are most likely to occur in the Lower Great Southern and Lower South-West areas in districts such as Albany, and Manjimup. Although, should the disease ever become widespread, it may never be so serious here as in cool temperate regions such as Tasmania and New Zealand, nevertheless it can in favourable seasons, such as the present, and in the absence of control measures, cause tremendous losses. That the disease undoubtedly possesses the ability to persist under conditions extremely adverse for its survival is also certain, for it has been recorded here in four out of the five seasons, 1935-36 to 1939-40, and there is little doubt that during the fifth season it was present but escaped detection.

It must be patent therefore, to all growers how rapidly Black Spot of apples would become widespread if uncontrolled, and indeed there are good grounds for believing that the situation would then soon become similar to that which exists to-day in connection with the Pear Scab fungus to which it is closely related and which has similar climatic requirements.

It is fortunate that growers realise the necessity of immediately reporting the presence of Black Spot so that prompt steps may be taken to deal with the situation, for although the immediate costs of eradication may be high, they are infinitesimal compared with the constantly recurring costs of routine control measures, which might otherwise be necessary.

All apple growers, both commercial and non-commercial, should therefore familiarise themselves with the symptoms of the disease, especially those on the leaves, for at an early stage of infection or in seasons unfavourable for its full development, Black Spot may then be more apparent on the leaves than fruit.

SYMPTOMS OF THE DISEASE AND LIFE HISTORY.

(a) *Leaf Symptoms.*

Symptoms of Black Spot upon the leaves may be of two distinct types:—(1) more or less localised spots; (2) diffusely spreading, sooty or smudgy in appearance.

The first type takes the form when young of small more or less circular greenish-brown, or greyish-green spots with radiating ramifications of the fungus at the margins, and which under a hand lens, have the appearance of a very much branched or tree-like structure.

Occasionally the ramifications of the fungus radiating outwards from a central point of infection and easily visible to the naked eye may also be observed. (Plate I.)

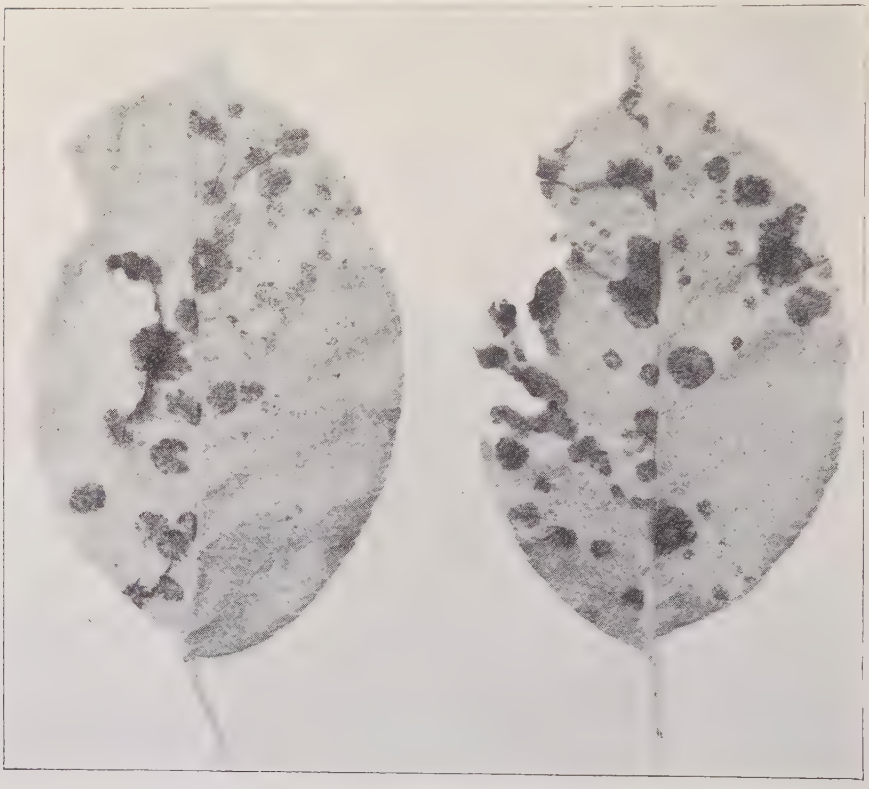

PLATE I.

"Black Spot" or "Scab" on apple leaves from Jardee, near Manjimup, January, 1940. Note the ramifications of the fungus radiating outwards from a central point of infection, in several lesions on leaf at left.

Later in the season, under favourable conditions, the scab spots may be covered with large numbers of spores, when they become olive green or almost black in appearance. If the spots are numerous, they may coalesce as they enlarge until ultimately nearly the whole leaf surface may be involved. (Plate II.) Frequently as the spots enlarge they become raised or blistered, the opposite surface becoming correspondingly depressed and the dark velvety surface then may become smoother, duller or sometimes shining and graphite like in colour, as the spores are rubbed, washed or blown away. Plate (III.)

PLATE II.

Apple leaves affected with "Black Spot" or "Scab" caused by the fungus *Venturia inaequalis* (Fusicladium dendriticum). Note on leaf at left numerous small localised lesions. On leaf at right the lesions along the main vein have enlarged and coalesced, ultimately almost the whole leaf surface may be involved. Near base of centre leaf two lesions have enlarged and their margins have just met.

In the second type of leaf infection, the fungus spreads diffusely, giving the leaf surface a sooty or smudgy appearance, and frequently the spread of the disease follows the direction of the main veins and occasionally the leaf stalk. (Plate IV.)

Both these types of leaf infection were noticeable in all outbreaks this year, but the localised spot form, later becoming blistered, was the more abundant; both the blistered and sooty or smudgy types were accompanied by considerable leaf distortion, Rarely were infections noted on lower leaf surfaces, where according to Cunningham (3) the earliest leaf infections occur.

(b) *Fruit Symptoms.*

"On the *fruits* the scab lesions first become obvious as small, brownish or black, irregular or circular spots without any break in the skin. With increase in the size of the lesions the *cuticle,* or transparent rubber-like coating over the first layer of cells, becomes ruptured, and the interior of the lesion then appears velvety and dark brown, or almost black, with an irregular and considerably frayed and torn, silvery-white, margin, which is the ruptured cuticle. This silvery-white and much lacerated

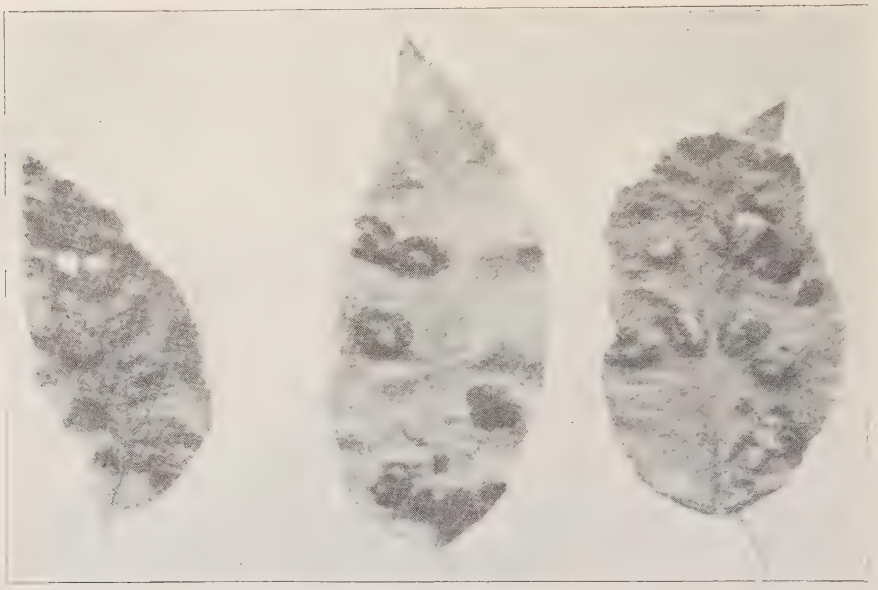

PLATE III.

"Black Spot" or "Scab" on apple leaves from Upper Kalgan, January, 1940. During enlargement the localised lesions frequently become upraised, presenting a blistered appearance, the opposite surface becoming correspondingly depressed. Lesions of this kind were abundantly present in all the affected orchards this season. Note distortion of the leaves at left and right. Lesions rather similar in appearance to the above caused by the closely related Pear Scab fungus are often seen on pear leaves in W.A.

cuticle can often be seen in the early stages with the naked eye (see plate 5) but it is, of course, much more readily distinguished with a hand lens. Under the lens the centres of newly-formed, smallish lesions, often have a mottled silvery-white and black appearance, due to the alternation of black patches of spores and pieces of ruptured cuticle. Many of the fruits infected in the early stages fall to the ground, but large numbers may persist on the trees. In such a case many of the infected apples will become badly distorted, owing to the more rapid rate of growth on the part of the healthy portions giving unsymmetrical development (see plate 6). With increase in the size of the fruits and the lesions, the centre parts of the diseased areas often become bare, and corky, and somewhat cracked or fissured, the edges of each lesion still, however, remaining infected and dark in colour, owing to the continual production of spores. It is this phase of the disease which has given rise to the common name of "apple scab." Once the centre of a fruit lesion has become hard and corky, any further increase in the growth of the still healthy portions of the fruit may lead to the development of very large and unsightly cracks in the diseased area. When fully-grown, or almost fully-grown fruits are

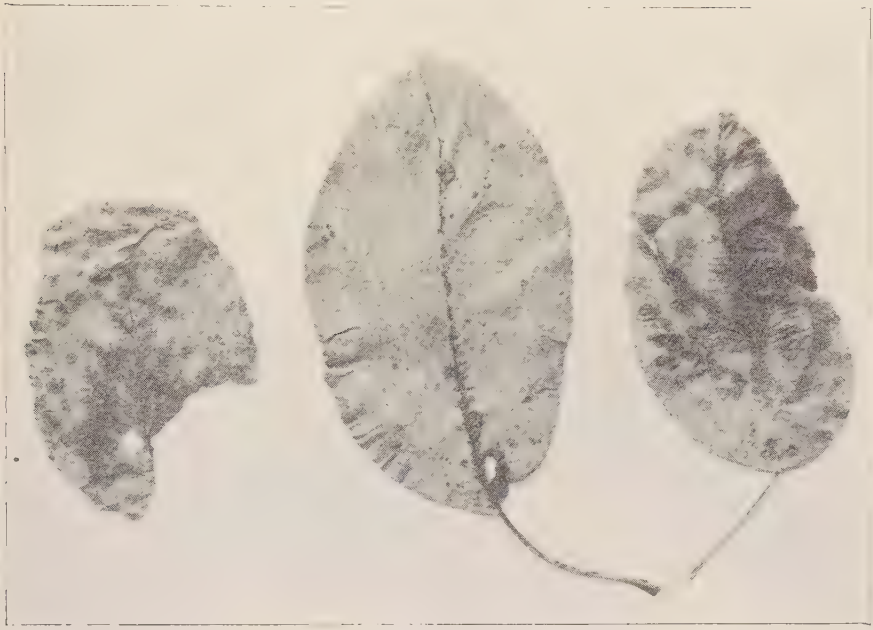

PLATE IV.

"Black Spot" or "Scab" on apple leaves from Upper Kalgan, January, 1940. The lesions of the "Black Spot" fungus on the leaves are of two distinct types, (a) more or less localised in definite spots (see Plate II.); (b) diffusely spreading, having a sooty or smudgy appearance. In type (b) the fungus usually spreads in the direction of the main veins. Note on leaf at left, smudgy appearance caused by the diffuse spread of the fungus; on leaf at right the general spread of the disease along the main veins can be clearly seen. Note also the sooty appearance and severe leaf distortion. On the centre leaf the fungus has spread upwards along the main vein, and downwards on to the leaf stalk.

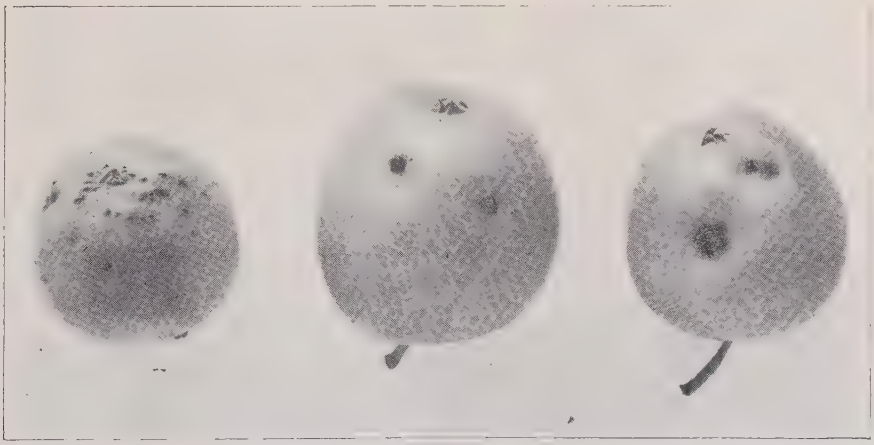

PLATE V.

"Cleopatra" apples from Jardee, January, 1940, affected with Black Spot. The apples were infected with the disease at different stages in their development. Apple at right infected at a fairly early stage shows considerable distortion. That on left infected at a much later stage shows so called "Pin Point" scab in which the fruit cuticle has just been ruptured by the developing fungus. Note also the silvery appearance of the ruptured cuticle around the margins of the lesions.

infected very late in the season, the lesions usually remain small, and the centres rarely become bare and corky. If apples recently affected with the scab fungus, or bearing *conidia* on their surfaces, are placed into cool or open storage, lesions may develop in the store (2).

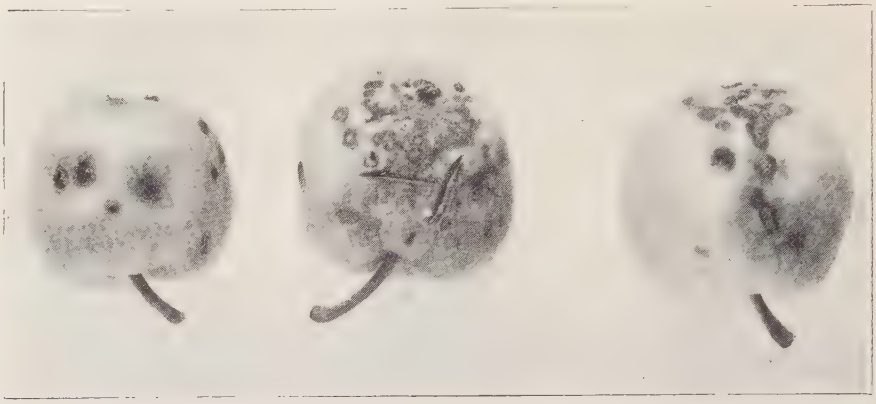

PLATE VI.

"Cleopatra" apples from Upper Kalgan, January, 1940. Affected with "Black Spot" or "Scab." Note the distortion of all fruits and the cracks in the centre apple.

(c) *Blossom Symptoms.*

The disease may also infect the blossoms causing lesions to appear on flower stalks and young fruits, petals or calyces.

Blossom infection considerably reduces the amount of fruit set and materially decreases the quality of much of the remainder.

(d) *Shoot Symptoms.*

Shoot infections have as yet not been noticed in Western Australia, but they are said to be confined to the bark of one-year old shoots. According to Heald (4). "Young lesions on the twigs are very similar in appearance to those on the fruits, showing the central spore surface borderd by the uplifted epidermis (skin). Later in the season the spores may disappear and the bark show a more scaly character, due to the peeling of the bark in flakes . . . The twig lesions may be few and scattered, and thus may be easily overlooked, or they may be so numerous as to coalesce and produce more extended affected areas" (2). The lesions on the shoots may play a part in carrying the disease over from season to season, where the winter conditions are mild, as they may, under such conditions, produce a fresh crop of *conidia* in the following spring.

VARIETIES AFFECTED.

Since the first outbreak of the disease in 1930, fruit infection has been noticed on the following main varieties, which are listed in what is considered to be the order of their susceptibility, the most susceptible being mentioned first.

The numbers in brackets refer to the number of times fruit infection has been noticed in different outbreaks of Black Spot:—Cleopatra (6), Granny Smith's (8), Yates (3), Dougherty (1), Dunns (2), Jonathan (2), Delicious (1).

RECOMMENDATIONS TO GROWERS IN THE VICINITY OF ANY INFECTED ORCHARD.

Prior to this season, outbreaks of the disease have never been discovered at one time or more than one orchard in each of two districts, whereas at present three outbreaks are known to exist both in the Upper Kalgan and Manjimup areas.

The apple growers in these two districts are thus confronted with a very serious situation which will require every effort on the part of all concerned if the disease is to be prevented from gaining a firm hold.

Those who already have the disease within their orchards *are* making every effort and with the aid of this Department, they are carrying out the prescribed measures for eradication faithfully and to the best of their ability. In order to make doubly sure that traces of the disease have not escaped the notice of inspectors on other orchards (and here the reader is reminded of the difficulty detection may at times present), all growers in the vicinity of these outbreaks, the locations of which are known to all concerned, are urged to carry out additional inspections and to be constantly on the watch for symptoms of the disease on leaves and fruit.

Furthermore, to guard against the introduction into other orchards of diseased leaves, which may be blown away before the cover crop has grown sufficiently to entangle them, growers in the vicinity of any outbreak are advised to adopt the measures previously described in Section 3, page 59, and in addition to apply the "spur burst" and "pinking" sprays, plus spreaders, at the stipulated strengths. Although the costs of carrying out these treatments will be substantial, *they only represent the minimum expenditure which would be required annually should the disease become widespread.*

There is one reassuring aspect of the present serious situation from which all apple growers (with the exception of those concerned in the affected areas) may derive satisfaction; all commercial orchards have been inspected this season by crop assessors of whose alertness mention has already been made.

It is hoped and believed, therefore, in view of the fact that the season has been most favourable for the development and the detection of the fungus that in commercial apple orchards all infection centres which at present exist have been discovered.

If the disease can be wiped out in these two districts, and this is by no means an impossible task, the growers in these areas will do themselves great service, and in so doing will earn the gratitude of all who have the welfare of the apple industry at heart.

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Oat, Wheat, and Barley Variety Trials in the Dairying Districts.

H. G. Elliott, Agrostologist.

These trials have been conducted for a number of years by officers of the Dairy Branch. In the March, 1938, issue of this Journal a resume of the trials for the 1937-38 season was published. The object of the trials is as follows:—

1. To determine the variety of oats (if any) that give higher rates of yield per acre than the variety "Algerian."
2. To determine if barley or wheat gives greater yields than the oat varieties.

During the season 1938, the wheat varieties were deleted from the trials, as the results for a number of years prior to that season showed that the wheat varieties did not give yields in any way comparable with the oat varieties.

Fertiliser.— In every case one bag or 180 lbs. of superphosphate was applied per acre. The rate of seeding was 2 bushels per acre for oats and 1⅓ bushels per acre for wheat and barley.

Method.—Each variety was sown in plots of ½ an acre and in triplicate.

The following Table 1 gives the results of the three trials conducted during the 1939 season, and one which was conducted during the 1938 season and not included in the previous report.

TABLE 1.

Trial.	Algerian.	Wongan.	Burt's Early.	Mulga.	Barley (Atlas).
J. A. Lynam, Bridgetown—					
Tons per acre	1·73	1·58	1·50	1·47	1·41
Yield (per cent.)	100	91·30	86·20	84·30	81·00
E. W. Strike, Brookhampton—					
Tons per acre	3·32	2·75	2·44	3·24	2·67
Yield (per cent.)	100	82·83	73·50	97·60	80·42
Research Station, Denmark—					
Tons per acre	2·84	2·46	2·62	2·82	1·46
Yield (per cent.)	100	86·62	92·43	99·47	51·40
Research Station, Denmark (1938)—					
Tons per acre	1·42	1·01	1·30	1·35	0·84
Yield (per cent.)	100	71·12	91·90	95·07	58·80

(Hay yields estimated.)

J. A. Lynam, Bridgetown.—Information supplied by A. M. Tindale, Dairy Instructor.[1] The varieties were sown on the 3rd July, 1939, on well drained red loam, which was originally timbered with jarrah and red gum. The land was disc plowed during early June, the oats drilled in and after drilling, harrowed. Oats were grown on this piece of land during the previous season.

E. W. Strike, Brookhampton.—Information supplied by A. M. Tindale, Dairy Instructor. The plots were sown on the 12th July, 1939, on red loam which was originally timbered with jarrah and red gum. For four years prior to the oats being planted the land had been under pasture which consisted mainly of subterranean clover. The land was plowed with a two-furrow mouldboard plow in the last week of May, the oats being drilled in and harrowed after.

Denmark Research Station.—The Plots were sown during the first week of May on light gravelly to sandy loam. The land, prior to the oat crop, carried the previous season a crop of Tick beans and prior to that had been under pasture for four years. The land was plowed with a disc plow and the oats broadcasted and harrowed in.

The average yield for all varieties for the three seasons is shown in the following Table 2.

TABLE 2.

Variety.	No. of Trials.	Hay.	Yield.
Oats—		tons per acre.	%
Algerian	11	2·33	100
Wongan	11	1·95	83·69
Burt's Early	11	1·98	85·00
Mulga	10	2·12	91·00
Barley—			
Atlas	6	2·30	98·71

It is anticipated that these trials will be conducted again during the coming season.

Pasture Development.

H. G. ELLIOTT, Agrostologist.

The fifth year's Report on the Rotational Grazing Demonstration under Irrigated conditions, being conducted on the property farmed by Mr. D. Moore and owned by the late Mr. A. E. Jackson, Roelands, is now available. This demonstration, along with those on the properties of Messrs. J. Neil and C. H. Henning, of Waroona and Hamel, respectively, has been conducted as a co-operative project by the State Committee of the Australian Dairy Produce Board Pasture Improvement Committee (W.A.) and the Field Staff of the Department of Agriculture*.

During the last five years the Australian Dairy Council has made available funds for the conducting of a number of experiments designed to increase and improve pasture production in Western Australia. The Dairy Council has now been merged with the Australian Dairy Produce Board Pasture Improvement Committee, which body has continued the work previously started, and has made increased funds available for further investigations. All the experimental work is controlled by the Western Australian Pasture Improvement Committee, working in close co-operation with the Department of Agriculture.

The initial objects of the demonstration were concluded last year, these being as follows:—

1. The collection of data regarding the carrying capacity of small areas.
2. The collection of information as to whether it would be more profitable to establish a permanent pasture with a cover crop than to sow Perennial pasture species alone.
3. The obtaining of the monthly yield of green material per acre.

*A resume of the first four years' operations have been published in the March, 1936, 1937, 1938 and June 1939 issues of this Journal.

4. The collection of botanical data to show the change in botanical composition due to rotational grazing under irrigated conditions.

The main object of the experiment during last season and this coming season is to obtain the following information:—

To test the effect of varying the time between waterings during the irrigation season, the information being obtained by means of grazing and yields. All information with reference to type of soil, seed mixtures used, fertiliser applied, initial cultivation, cover crops and irrigation have been given in detail for each field in the previous reports. The following details give further results of the experiment for the year ending 31st December, 1939:—

Fertiliser:—The rate of application of fertiliser for the fifth year (1939), was slightly higher than that of the fourth year, being 6 cwts. per acre, applied in three applications, the main application of 3 cwts. being given in the autumn. Table 1 gives the rate of application of fertiliser for the five years:—

TABLE 1.

Year.	Fertiliser—lb. per acre.		
	Superphosphate.	Sulphate of Ammonia.	Lime.
1935	904	218	...
1936	374	28	448
1937	600	...	...
1938	560	...	...
1939	672	...	...

From the above Table it will be seen that the highest rate of application was given during the initial year of establishment. In this year some 904 lbs. super and 218 lbs. sulphate of ammonia were applied. During 1936 only 28 lbs. sulphate of ammonia were applied, and since that date no further applications of nitrogenous fertiliser have been given. Agricultural lime was applied only in 1936 over half of each field at the rate of 4 cwts. per annum. No effect from this application has been noticed to date. In no instance has potassic fertiliser been used. The basis of application of fertiliser during the last two years has been derived from fertiliser experiments which have been conducted under irrigated conditions on other properties. Here indications show that at least 6 cwts. are required per annum, the heavier rate of application being given in the autumn. In these experiments indications show that very little effect was obtained under irrigated conditions from the spring application of superphosphate. However, there are factors to show that summer applications, given just prior to irrigation, are profitable. Here it is recommended that at least 1 cwt. be given prior to watering, either in the months of December, January, February or March. It is possible that the December and March applications will be the most profitable.

Renovation:—A second renovation was carried out on all the fields during June of 1939. The first renovation was carried out in the middle of July, 1938. In both instances, all plots received a severe surface renovation with a rotary type of renovator known as, the "Sun-prong." Following the double renovation pasture blade type of harrows were used with half-chain harrows following the blade harrows. The effect of this second severe renovation was shown in the yield and grazing obtained from the area following the operations. It is considered that no surface renovation will be required over the area for at least another

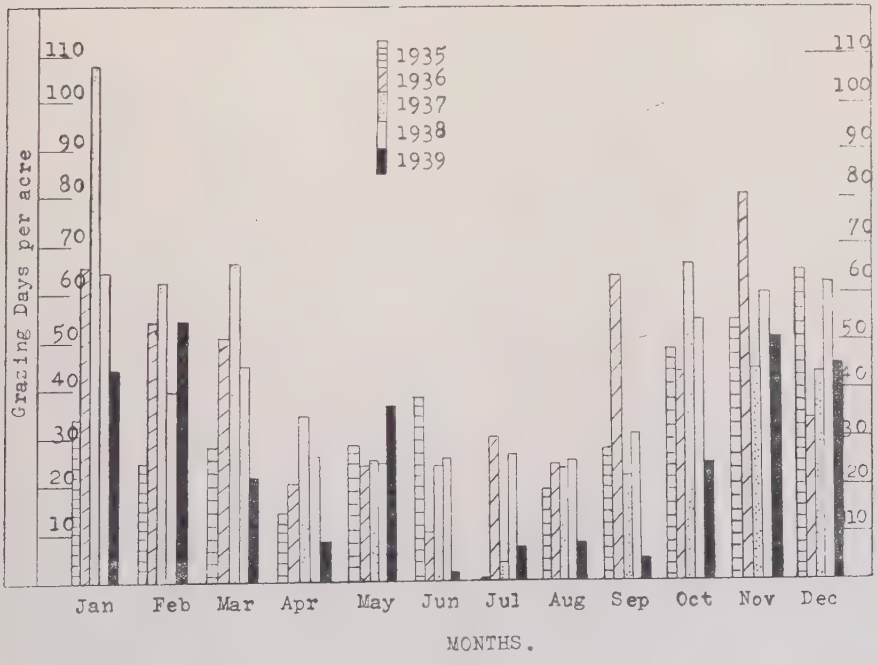
3-4 years. The necessity for the use of chain and blade harrows is obvious on small areas which are being grazed heavily. This operation is required to assist in breaking up animal droppings and spreading them sufficiently to obviate rank patches and growth, which normally occur wherever animal droppings are present on the pasture. During July, 1938, all the irrigation furrows were cleaned out with a modified type of "Sun-buster" plow. This operation was necessary to facilitate watering during the summer months. The complete area was topped twice with a mower during the summer to assist in preventing seed production of the paspalum, also to assist in controlling the spread of Ergot.

Weeds:—The control of rushes and Rats' Tails (*Sporobolus indicus*) was carried out during the year. It was found necessary to hand grub sections where these weeds occurred in quantity. Fairly good control has now been obtained.

Irrigation:—As mentioned in the last report in the June 1939 issue of this Journal, the system of irrigation has been altered to enable the Irrigation Officers to carry out a Time of Watering experiment. It is anticipated that the final information from this experiment will be available by the end of June. The following information gives in detail the method which has been adopted by the Officers of the Irrigation Branch for watering the individual paddocks. For the purpose of the work a water requirement of 1½ inches per week has been adopted tentatively. On this basis Field No. 3 is watered at intervals of two weeks, Fields Nos. 2 and 4 at intervals of three weeks, and Fields Nos. 1 and 5 at intervals of four weeks, receiving respectively 2¾ inches, four inches and 5½ inches of water per irrigation, the water being measured by a series of guages installed for this purpose.

Grazing:—The following Graph 1 gives the average monthly grazing days (8 hours) per acre obtained from the area for the years 1935-1939 inclusive.

Graph 1 - Average Monthly Grazing Days (8 hours) per acre.



From the above Graph it will be seen that the monthly production in grazing days per acre for the five fields was 25.6. This is very much lower than that of the previous years—1938, 40 grazing days per acre; 1937, 42.2 and 1936, 41.3. The months in which the greatest reductions took place are those of March, April, June to October inclusive. It is difficult to explain why a reduction in grazing took place during March and April. The reduction of grazing during the period June to October is due mainly to two factors:—

1. Excessive grazing during May.
2. Effects of severe renovation.

The beneficial effects of this renovation will be more noticeable during the coming season. Another factor which possibly contributed to the low production during these months was the effect of the watering programme on Plot 3. This gave a much lower grazing than the other plots for the year. Seasonal conditions also played an important part during the spring months on production. The month of September, during 1939, was the driest September on record for many years. Consequently all pasture suffered during this period and during the following month. The usual high flush did not occur. Irrigation commenced early in November, consequently, the production for November and December is equal to that which was obtained during the previous years. The total grazing obtained from all fields averaged 307.3 grazing days per acre per annum. This of course, is much lower than that obtained during the previous years, the average for 1938 being 480.5. Owing to the reduction in grazing obtained during the month of January, a slight increase was obtained for February. The amount of grazing obtained during February, however, was not much above the average of previous years. The previous three years' decline which occurred in feed through February grazing was followed by an increase during March. This, however, was not the case during the last season. Under irrigated conditions, the months April to August inclusive are definitely the lowest production periods of the year. Table 2 gives the full grazing production for the years 1935-1939 inclusive.

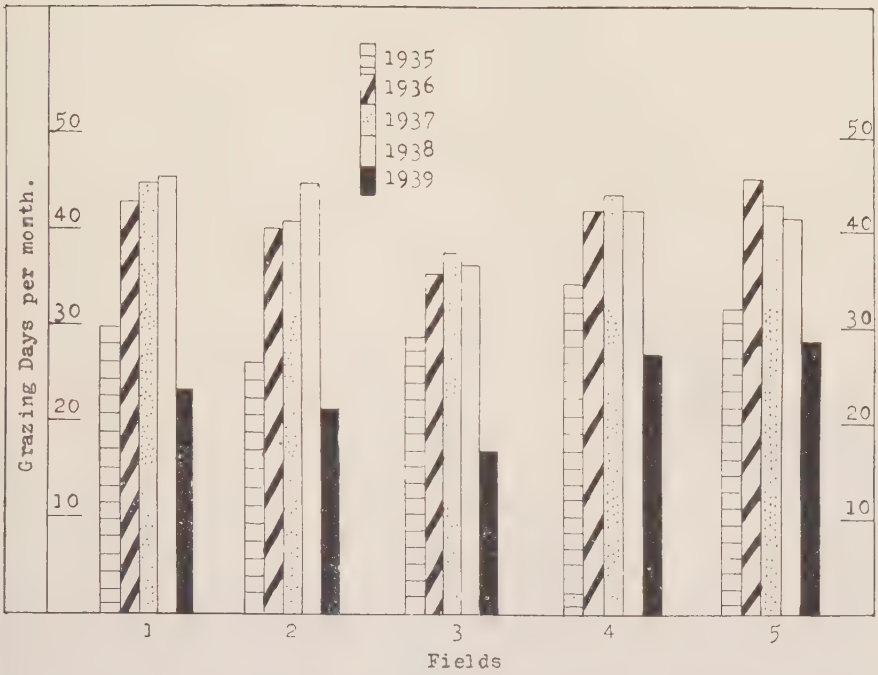
TABLE 2.

Year.	Grazing Hours.	Total Grazing Days.	Grazing Days per Acre.	Acres per Cow.
1935	38,373	4,796·6	371·2	0·97
1936	47,019	5,877·4	496·1	0·73
1937	52,200	6,525·0	506·6	0·72
1938	49,430	6,178·7	480·5	0·76
1939	30,001	3,750·0	290·7	1·25

From the above table it will be noted that the complete area has maintained a relatively high carrying capacity, and during the three years 1936-1938, a very high carrying capacity which was fairly constant, being equivalent to approximately one cow to ¾ acre. It will be noticed, however, that for the year 1939, the carrying capacity was only one cow to 1.25 acres.

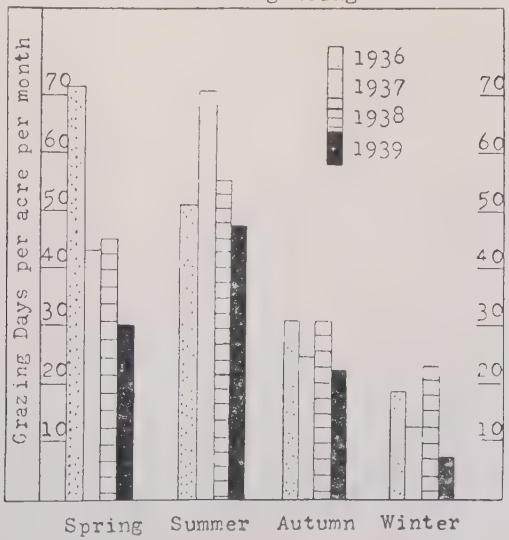
The following Graph 2 shows grazing days per acre obtained for the individual fields for the years 1935-39. The most marked annual variation occurs in Field 3. This, however, has been accentuated to some extent by the present system which has been adopted with reference to irrigation. This field, as explained in previous reports, originally had the heaviest cover crop, i.e., Japanese Millet. The effect of this cover crop in the earlier stages was most marked, more particularly with reference to the spread of White Clover and also the method in which couch grass

Graph 2 - Grazing Days (8 hours) per acre



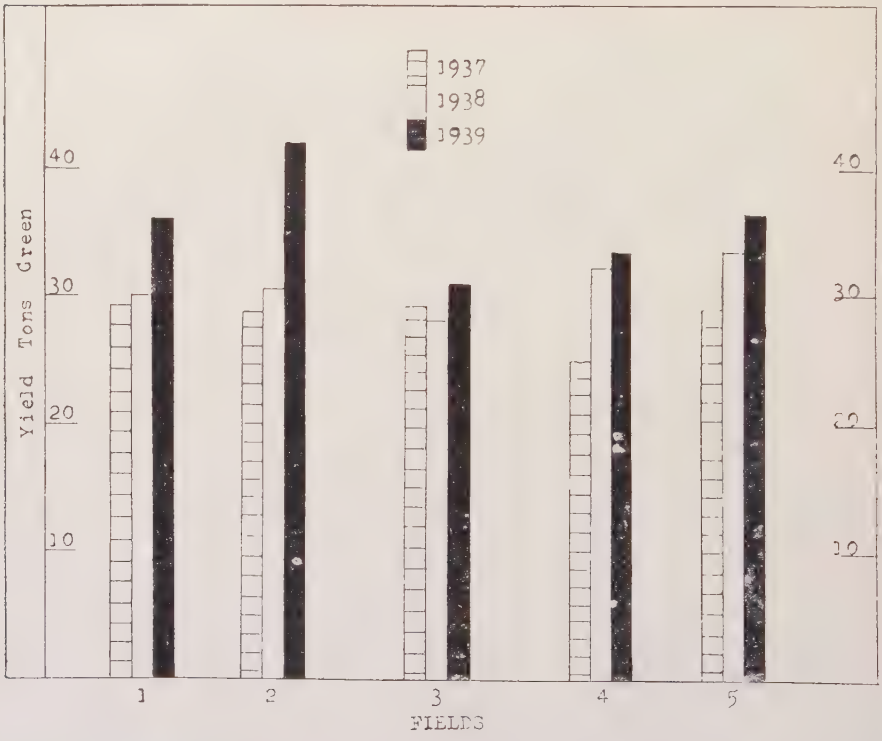
dominated sections of the area. It was very obvious from the results obtained in this field, that no beneficial effects were obtained in establishing permanent pasture under irrigated conditions with a heavy cover crop. Even the additional yield during the first year of this heavy cover crop did not bring about the highest production in grazing for the first year. No definite information, however, can be given with reference to the effect of the variation in watering practice being adopted over these fields, as the experiment is not yet completed.

Graph 3 - Showing three-monthly seasonal grazing



Graph 3 shows the monthly variation in grazing days which occurs during the three-monthly seasonal periods of the year. From this it will be noticed that the summer production for the last season was very similar to that obtained for the previous three years. The spring production, however, was considerably lower, the autumn production slightly lower and the winter production very much lower than the previous three years. The low production during the spring months has been explained earlier in this article, this being due to lack of rainfall during the month of September, also the residual effect of the severe renovation during the winter months. The excessive grazing during May and the renovation which took place during June, lowered the winter production. It will be noticed from Graph 5, however, that the three-monthly seasonal yield was very low during the winter months.

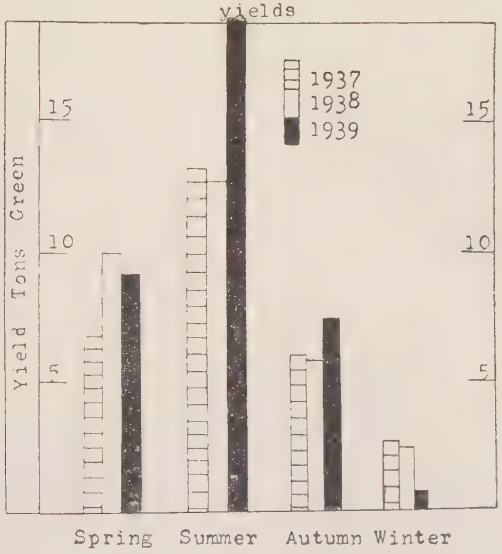
Graph 4 - Annual Production in tons, green, for the five Plots.



The above graph gives the annual production in tons of green material for the five fields for the years 1937-1939 inclusive. It will be noticed from this graph that the production of green material in tons for all fields was slightly higher than the previous year. This shows that the production of green material was high although the amount of grazing obtained for the year was much lower than the previous two years. The reason for this low grazing has been explained previously. The excessive grazing during May affected the amount of grazing obtained considerably, and also owing to the farmer being short of feed elsewhere during the winter and early spring months, a much quicker rotation of grazing occurred than was laid down for all fields. This, consequently, retarded the recovery of growth with a corresponding reduction in grazing days obtained. During the period 1937, the average production for the whole area was 28.1 tons per acre, in 1938, 30.5 tons per acre and for 1939, 36.1 tons per acre. This graph also

shows that for the three years in which yields of green material have been taken, Field 3 has given over the last two seasons a lower average of production than the other fields. This reduction in yields has occurred since the alteration in irrigation practice has taken place. When this rate of watering experiment has been completed, full information with reference to production and grazing will be related to the system of watering adopted.

Graph 5 - Showing three-monthly seasonal yields



Graph 5 gives the three-monthly seasonal yields in tons of green material for the three years 1937-1939 inclusive. It will be seen from this graph that the heaviest production occurs during the summer months, December-February. A much heavier yield of green material was obtained during the last summer than for the previous two summers. The spring production, however, showed very little variation, but the autumn production showed a slight increase over the previous two seasons. With the winter production there is a serious decline. Actually during the year 1937, 48.6% of the production occurred during the summer months, in 1938, 42.6% and in 1939, 52.3%. In the spring the production for 1938 showed a decided increase over 1937, being 33% of the total production. In 1939, however, it was 24.1%. It will be seen that for the period September to February inclusive, 1938, 75.6% of the production was obtained. In 1939, however, 76.4% was obtained. The winter production for 1937 was 7%, for 1938, 6% and for 1939 less than 4%. The 1939 figure showed a serious decline. This shows that these three months are undoubtedly the ones when the least amount of grazing can be expected. Consequently it is necessary for farmers to have ample conservation for the winter months and also for the other lean period, the autumn.

C. H. Henning, Hamel.

Full particulars with reference to the establishment, cultivation, soil type, seeding, etc., of this experiment have been given in the March issue of the 1937 Journal. The objects of the experiment are:—

1. To determine the most suitable grass species in association with White Clover for the establishment of a permanent pasture under irrigated conditions on the soil type selected in this irrigation area.

2. The collection of information regarding the carrying capacity of pastures on small irrigated areas.
3. To determine the yields per acre of green material of various species under existing conditions.

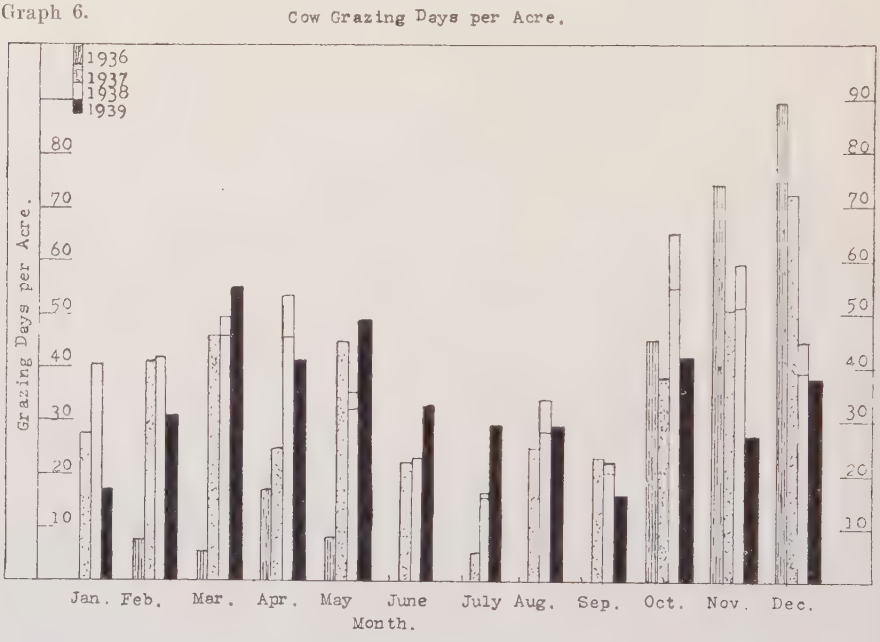
Irrigation:—During the past season four waterings were given, these being in January, February and November-December. The method of watering was similar to that used on the experiment being conducted at Roclands, i.e., the furrow system being adopted throughout.

Fertiliser:—Three fertiliser applications were given during the season. In each instance 2 cwts. were applied, the first prior to irrigation in February, the second in May and the third in September. During the previous season a total of 4 cwts. was applied in three applications.

Renovation:—It was considered that it would not be necessary to renovate the area during the last season, as it was sufficiently renovated during 1938. During the year, however, control of rushes was carried out.

Grazing:—The following Graph 6 shows the grazing days per acre obtained per month for each field for the past three years:—

Graph 6.



Note:—Graph showing grazing days (8 hours) per acre in the lower line of 1938 column gives grazing days per acre for all fields Nos. 1-5. Field No. 5 was not incorporated in this year's results.

From the above graph it will be seen that considerably more grazing was obtained for the months of March, May, June and July than that obtained for the previous three years. It is rather pleasing to note the increase in grazing which has taken place during the winter months. The production for the months September-December inclusive, however, showed a slight decrease, this being brought about by phenomenally dry conditions during September. Irrigation had to be carried out at an earlier date during last season than for any preceding year.

Table 3 gives the carrying capacity of the experiment for the four years, 1936-1939.

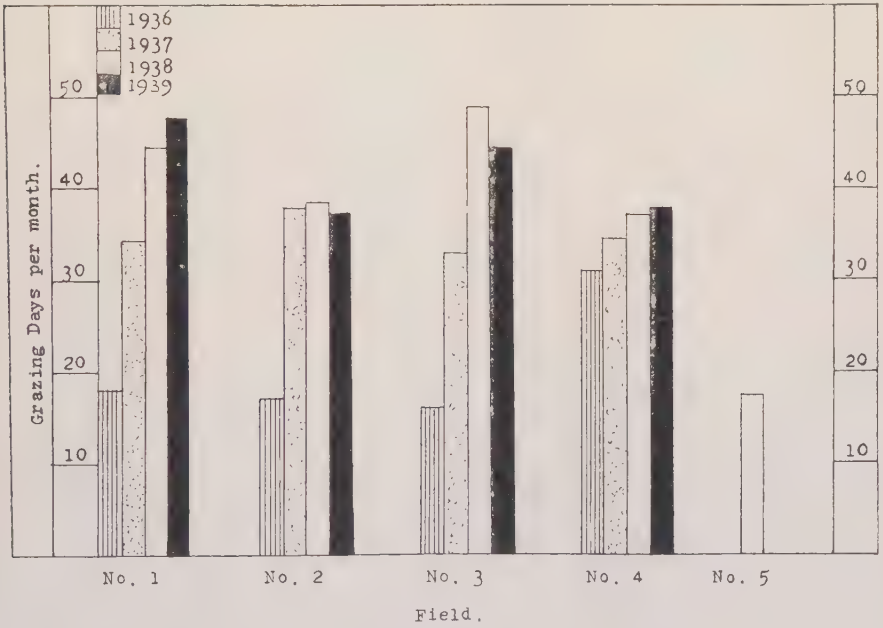
TABLE 3.

Year.	Grazing Hours.	Total Grazing Days.	Grazing Days per Acre.	Acres per Cow.
1936	16,504	2,063	250	1·46
1937	28,680	3,585	434·5	0·84
1938	32,957	3,990	499	0·73
1939	33,328	4,166	508	0·72

From the above Table it will be seen that the carrying capacity over the last three years has been very constant, being approximately 1 cow to 0.76 acre.

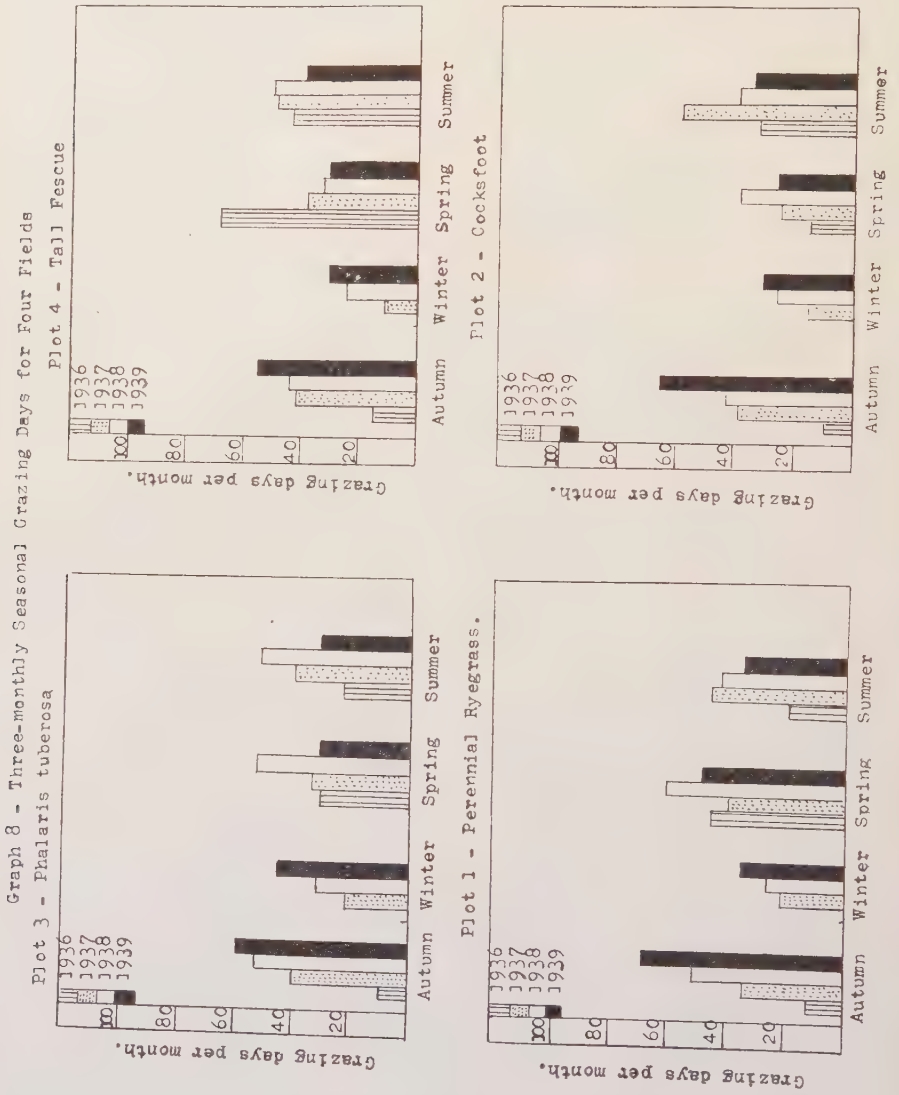
The following Graph 7 shows the average grazing days per month for the 12 months of each year 1936-1939 inclusive, for the various grass species in association with White Clover.

Graph 7. Cow Grazing Days (8 hours) per acre.



The average grazing days per month for Fields Nos. 1-4 for the year 1937, as shown in Graph 7, were 35, for 1938, 41.6 and for 1939, 42.2. It will be seen from this that there has been a slight increase during the last three years. It will be noted that Field No. 1 is still showing a steady increase in grazing days. Field No. 4 is still showing a slight increase over previous years, and Field No. 2 has remained relatively constant during the past 3 years. A slight decrease has occurred in Field No. 3 during the last season over the grazing obtained for 1938.

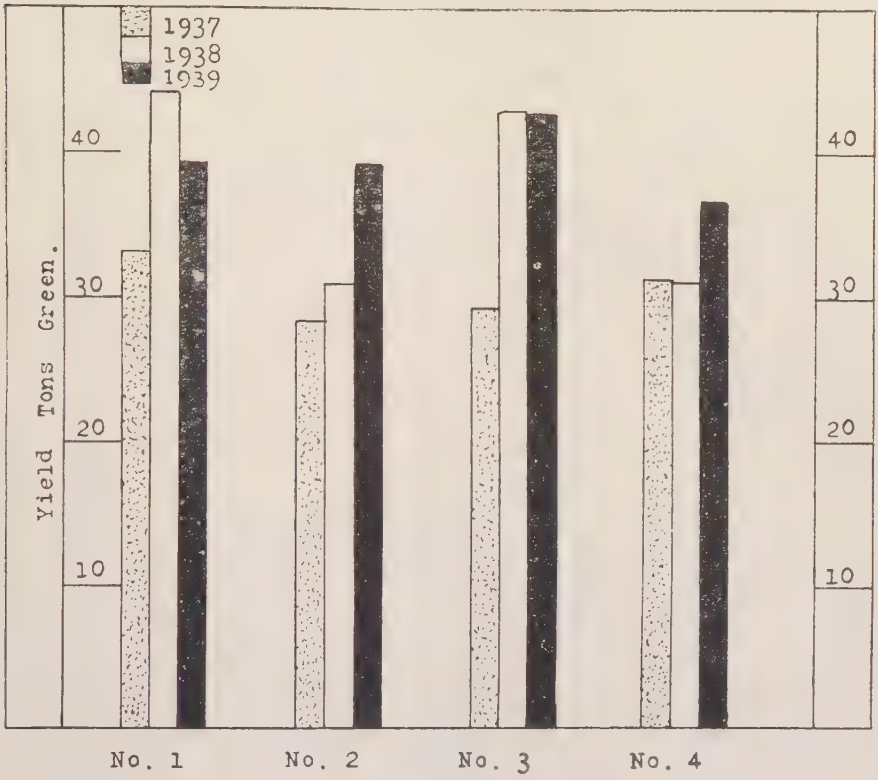
The following series of Graphs in Graph 8 show the quarterly grazing figures in each field for the four years 1936-1939 inclusive.



An examination of these graphs will show that the autumn production in every field is showing an increase over that of the previous years. Actually, there has been a steady increase in production during the autumn from every field for the years 1936-1939. Another interesting feature is the steady increase which is taking place in the grazing obtained during the winter months from all fields. It will be noticed from the series that Plot 3, *Phalaris tuberosa* and White Clover, is still giving the highest grazing figures for the winter period. In every case the spring production has declined from that of the previous year 1938, but was fairly constant as compared with that of the preceding years. The summer production had also declined from that of the preceding year. As the autumn and winter production are normally our two weakest periods for grazing, it is pleasing to note the increase which has been obtained for these periods.

Yields of Green Material:—The following Graph 9 gives the yields of Green Material which were obtained from each Field for the three years 1937-1939.

Graph 9. **Annual Production in Tons for the Four Fields.**



It will be seen from the above Graph that the production has increased for Fields Nos. 2 and 4, has remained constant in Field No. 3 and a slight reduction has occurred in Field No. 1. The average production for the year 1939 was 39.5 tons per acre, this being approximately 2 tons per acre in excess of that obtained for 1938, and 9 tons above that obtained during the year 1937. The production for the four fields in tons of green material for 1939 was relatively constant, being 39, 39, 43 and 37 tons per acre for Fields Nos. 1-4 respectively, the highest production being obtained in Field No. 3, *Phalaris tuberosa*.

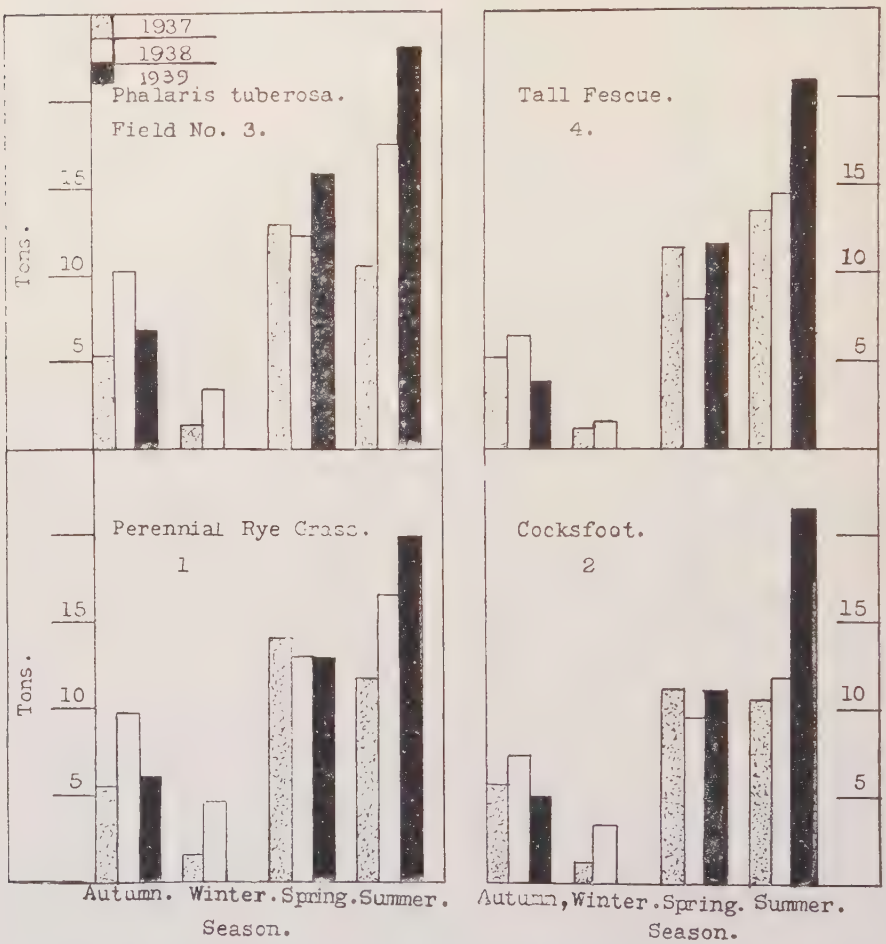
The production variations for the four fields for the period August-December inclusive for the four years, is given in the following Table 4.

TABLE 4.

Year.	1.	2.	3.	4.
	tons.	tons.	tons.	tons.
1936	12·7	11·1	10·6	8·1
1937	17·7	14·1	15·2	15·8
1938	23·9	17·9	22·9	15·8
1939	19·5	19·6	19·5	17·6

From the above Table it will be seen that the production from Fields Nos. 1, 2 and 3 were the same for the period August-December. There is a slight reduction in Field No. 4. The total production was slightly lower throughout that period of the year but Fields Nos. 2 and 4 showed a slight increase on the previous year.

Graph 10. Three-Monthly Seasonal Yields for the four Fields.



The following Table 5 gives the average three-monthly yields per acre for all plots for the four seasons of the year.

TABLE 5.

Year.	Autumn.	Winter.	Spring.	Summer.
	tons.	tons.	tons.	tons.
1937	5·3	1·3	12·6	11·3
1938	8·4	3·2	10·9	14·7
1939	5·5	...	13·0	21·5

It will be seen from the above Table that the production for autumn last season was approximately the same as for 1937, and slightly below that of 1938. The winter production, however, showed a relatively serious decline in yield of green material in tons per acre. The spring production showed a slight increase, whereas the summer production showed quite a considerable increase over the preceding years.

Graph 10 gives the three-monthly yield per acre for the four Fields for the three years.

The autumn production for all fields for 1939 showed a decrease over that obtained for the year 1938. In every case no winter production was obtained, although during the previous two seasons a light tonnage was recorded. In Field No. 3, however, there was a decided increase in production for the spring months. With the other three Fields the production was equivalent to that obtained during the previous three years. In every case the summer production had increased considerably. The absence of winter production was due mainly to the excessively wet conditions prevailing during these months, and no vast increase in the spring production was due to the dry September. The greater summer production was due to the increase in growth obtained following watering. While full observations will not be completed until the end of this season, some tentative conclusions appear legitimate. They are given at the end of this article.

J. Neil, Waroona*.

The objects of the experiment are the same as those given for C. H. Henning, Hamel.

Fertiliser:—A total of 6 cwt. of superphosphate per acre was applied in three applications of 2 cwts. each during January, May and September, the January application being given just prior to watering. A similar rate of application was given during 1938. Four applications totalling 702 lbs. were given during 1937 and 900 lbs. plus 100 lbs. sulphate of ammonia was given during 1936.

Irrigation:—During the year the Fields were irrigated five times, January, February, March, November and December. The period between the waterings in November and December was 40 days and this length of time between application of watering is being reflected in the production obtained from the fields during the earlier part of this season. Prior to the December watering the complete area was showing the effects of drought conditions.

Renovation:—As the whole area was renovated with a Sun-prong during 1938, it was not deemed necessary that this operation be carried out again last season. However, the complete area was harrowed twice with a blade type of harrows. Topping was carried out only during January.

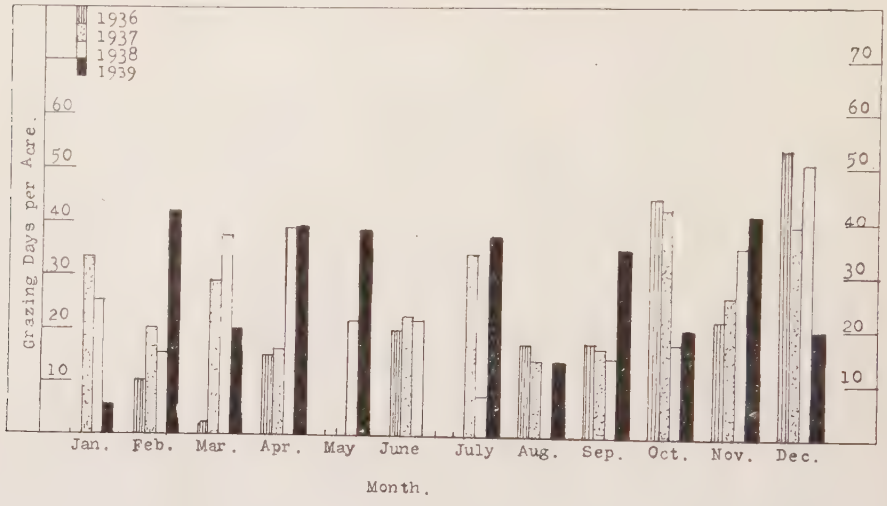
Grazing:—The following Graph 11 gives the grazing days obtained from each Field for the years 1936-1939 inclusive.

From this Graph it will be seen that the amount of grazing obtained during the months of January and March was lower than the preceding two years, but for February it was more than double that obtained during 1937 and 1938.

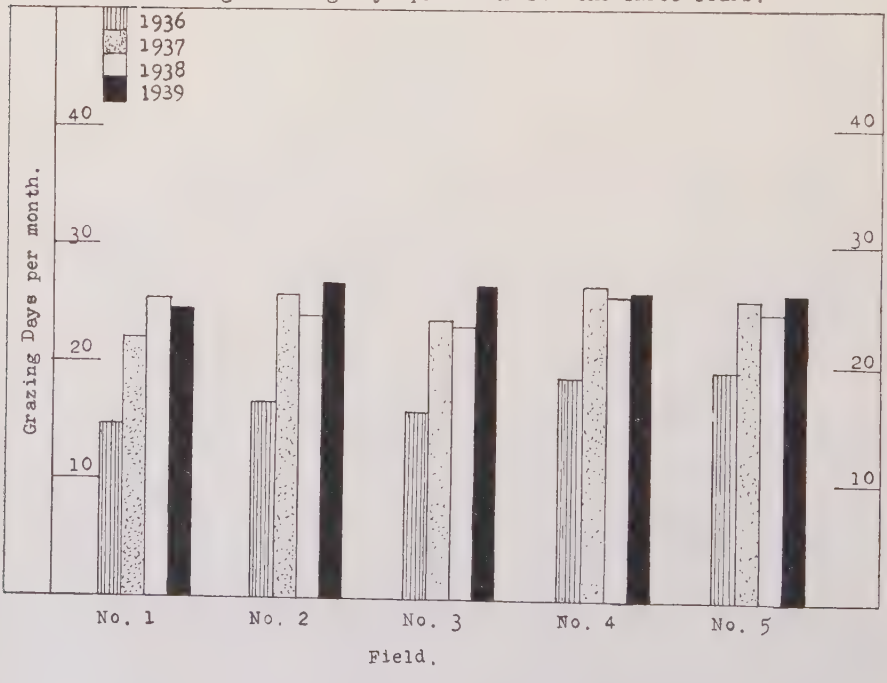
*Full particulars with reference to soil, cultivation, sowing, etc., have been supplied in the March, 1939, issue of this *Journal*.

The May and July production was also greater than previously, but no grazing was obtained for the month of June. The December production was about half that of the previous years.

Graph 11. Cow Grazing Days per Acre.



Graph 12. Average Grazing Days per month for the Three Years.



The following Table 6 gives the carrying capacity of the whole area for the four years 1936-1939.

TABLE 6.

Year.	Grazing Hours.	Total Grazing Days.	Grazing Days per Acre.	Cows per Acre.
1936	20,952	2,619	203	1·80
1937	30,3 4	3,798	294·4	1·24
193	29,891	3,736	285·8	1·28
1939	30,073	3,759	320	1·14

From this table it will be seen that the actual grazing obtained for the area was slightly better than for the three preceding years, being one cow to 1.14 acres. This was mainly due to the increased production obtained for the months February, May, July, September and November. The excessively wet conditions during June were probably the cause of the absence of grazing for that month. The effect of heavy grazing during November may have been instrumental in giving lower grazing figures for December.

The various grass species in association with White Clover gave an average grazing days per month for the years 1936-1939 as shown in the preceding Graph 12.

It will be seen from this graph that each species gave practically no variation in the grazing days per month for the four seasons, this again being due to some extent to the system of grazing adopted by the farmer each year.

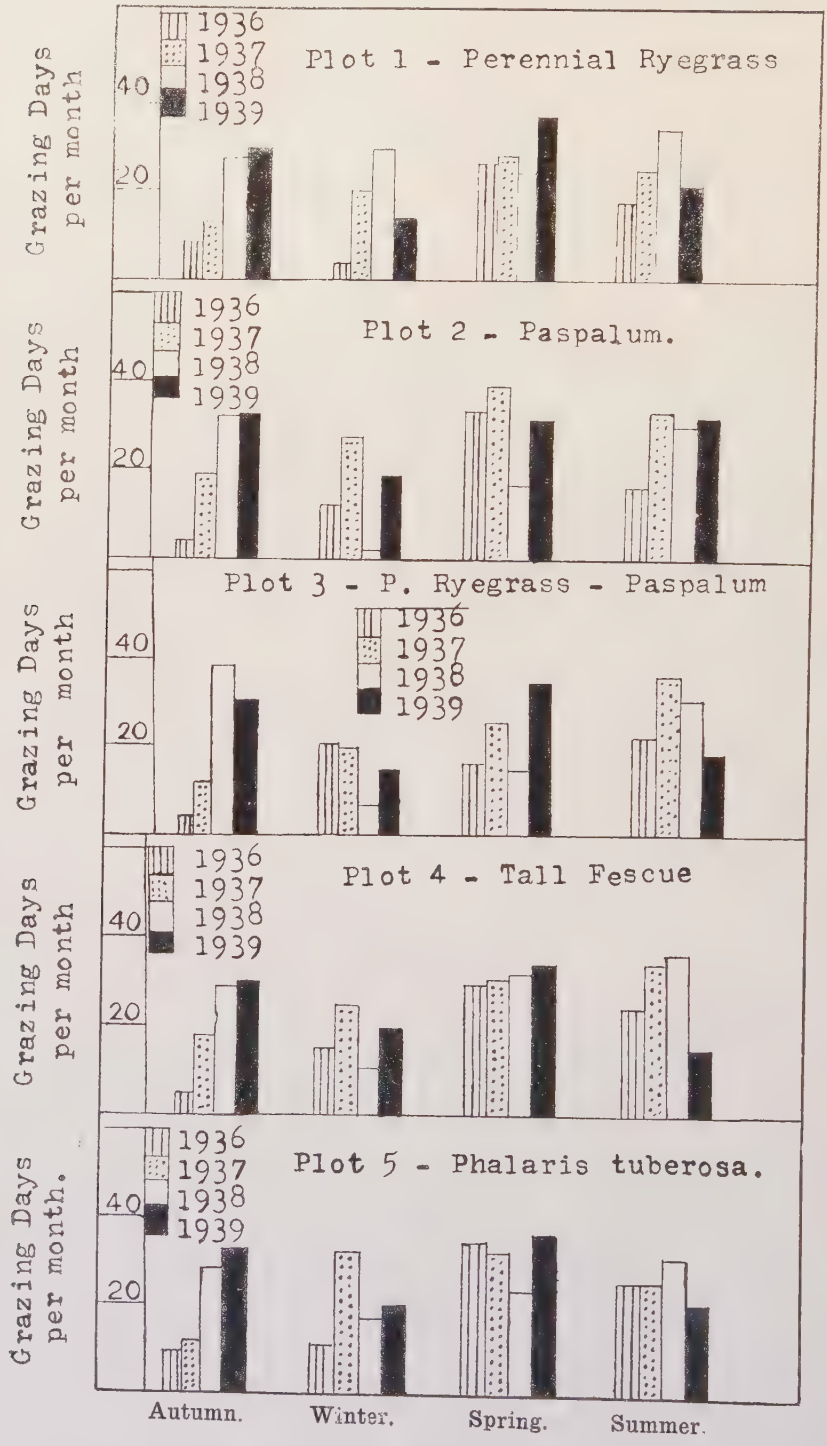
Graph 13 shows the three-monthly seasonal grazing days for the five Fields for the four years.

From the following series of graphs grouped in Graph 13 it will be seen that the spring production was slightly above the average obtained for the previous year. With Plots Nos. 1-3, however, a decided increase has taken place over the average production during the spring months for all years. An increase in the winter production occurred on all plots with the exception of Plot No. 1. Autumn production throughout remained fairly constant with that obtained for the previous season. There was a serious decline in the summer production on all plots, with the exception of Plot No. 2, this being Paspalum and White Clover association. The results throughout probably were affected to some extent by the system of grazing which was adopted by the farmer during the season. No definite information could be obtained during the past two seasons as far as grazing was concerned.

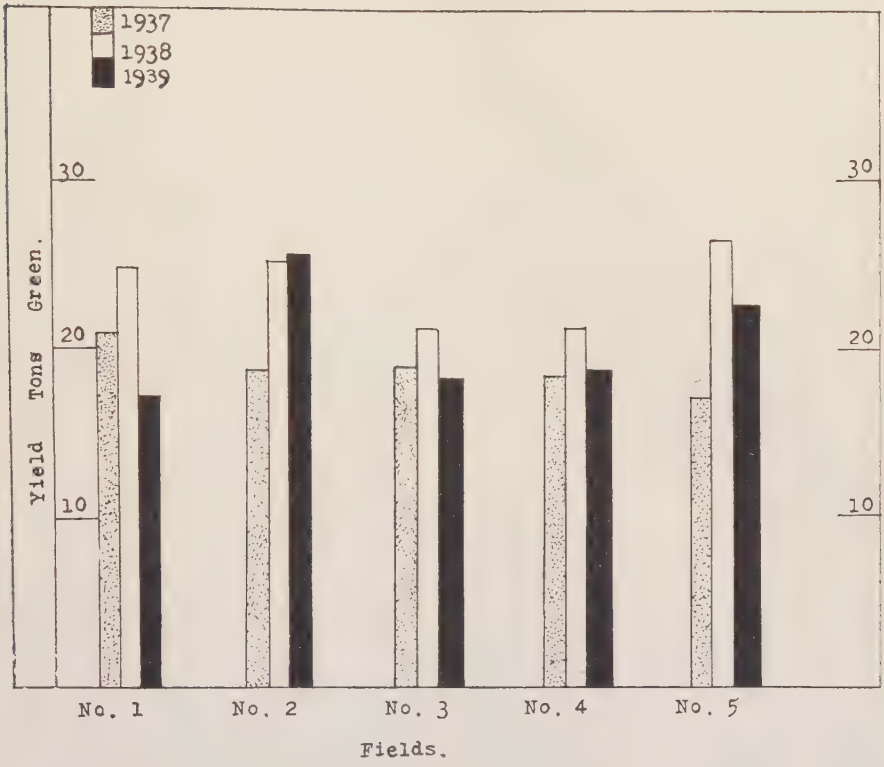
Yield of Green Material:—Graph 14 shows the yield of green material obtained per acre for the five Fields for the three years.

From this Graph it will be seen that Field No. 2 only gave the same yield as the previous year. All the other fields gave much lower yields. The average production per acre for all fields for 1939 was 20.4 tons per acre; for 1938 it was 23.9 tons, and for 1937, 18.9 tons.

Graph 13 Three-monthly Seasonal Grazing Days for the Five Plots.



Graph 14. **Annual Production in Tons for the Four Fields.**



The following Table 7 gives the production per acre for the three-monthly seasons of the years 1937-1939.

TABLE 7.

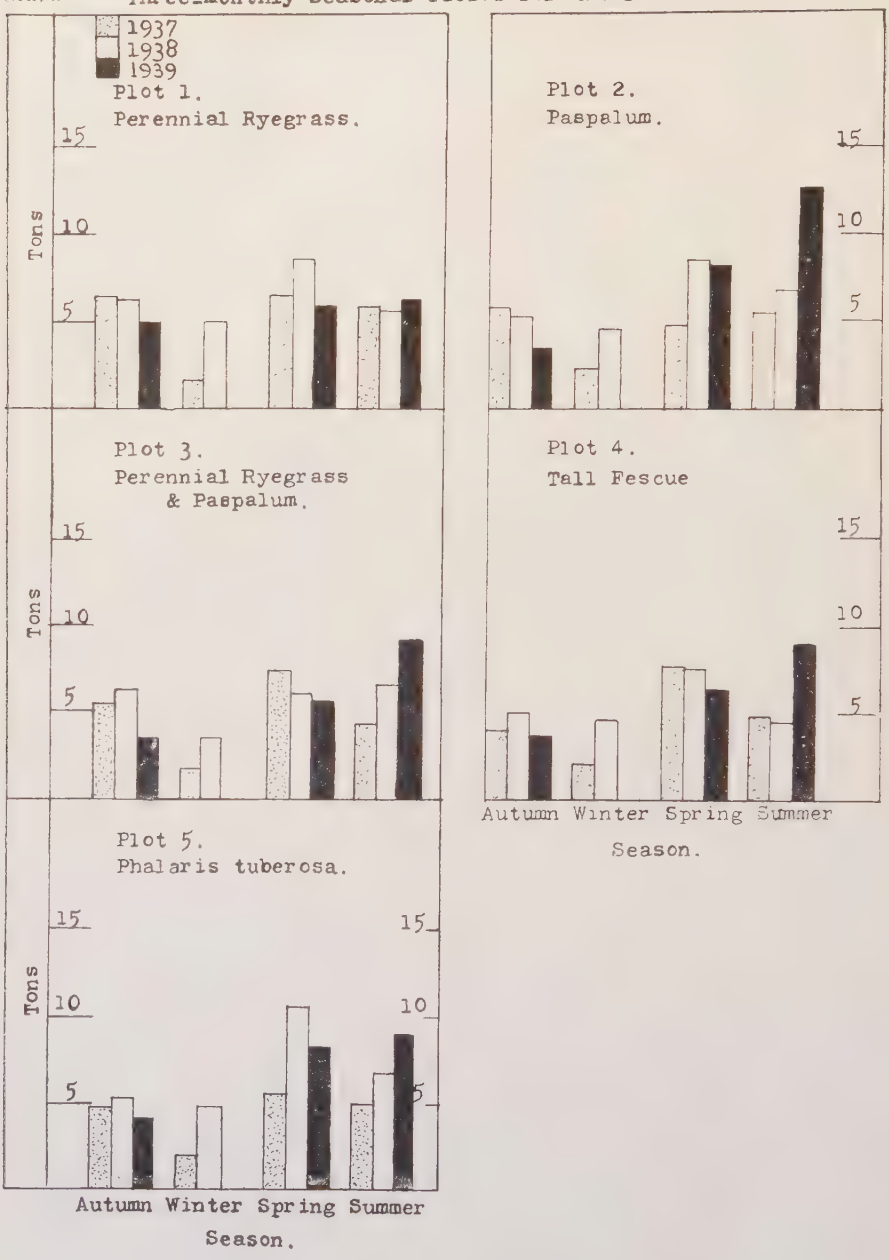
Year.	Autumn.	Winter.	Spring.	Summer.
	tons.	tons.	tons.	tons.
1936	...	...	...	...
1937	5·4	2·0	6·4	6·8
1938	5·4	4·5	8·2	5·8
1939	5·0	...	8·7	11·8

It will be seen from this table that the autumn production was practically the same as the previous years. The winter production, however, was negligible for 1939, whereas during the period 1937 it was 2 tons per acre, and 1938, 4.5 tons. The spring production was equivalent to that of 1938, but the summer production increased considerably, being 11.8 tons as against 6.8 tons for 1937 and 5.8 tons for 1938.

Graph 15 shows the three-monthly yields for the different seasons for each Field.

As will be seen from this graph, vastly increased production occurred during the summer on Plots Nos. 2 and 4, and a slight increase occurred on Plots Nos. 3 and 5, whereas Plot No 1 showed approximately the same production. The most outstanding feature was the lack of winter production for all Plots during 1939. Very little variation occurred in the production during the autumn and spring on all plots.

Graph 15. **Three-Monthly Seasonal Yields for the Five Fields.**



ACKNOWLEDGMENTS.

Grateful acknowledgment is made to Messrs. H. K. Gibsone and L. C. Lightfoot, Irrigation Officers, Roelands; Mr. T. Lutz, Agricultural Adviser, Waroona, and Mr. G. Brown, Field Technician at Head Office, for assisting in collecting the field information and compiling the figures given in this article.

Tentative Conclusions:—The results from the foregoing have shown that:—

1. Rapid growing cover crops are definitely detrimental to the initial establishment of White Clover, but not to paspalum. If Couch Grass (*Cynodon dactylon*) is present at the time of seeding, more particularly in the spring months, heavy cover crops will definitely assist the spread of this grass to the detriment of the sown pastures.

2. From the results obtained, rapid growing cover crops are not recommended when establishing permanent pastures under irrigation.

3. Rates of superphosphate up to 6 cwts. per acre are considered profitable, and at least 4-6 cwts. should be applied annually in 2 or 3 applications, the heavier rate (3-4 cwts. per acre) being applied in the autumn. Indications from the experiments being conducted show that summer applications of superphosphate just prior to irrigation are definitely profitable.

4. Superphosphate and sulphate of ammonia mixtures can only be recommended in the initial stages of establishment, more particularly at the time of planting.

5. Excessive and continuous grazing during the autumn and winter months seriously retard the production of the pasture.

6. It is not recommended that closer grazing periods than 20 days should be carried out. This applies to the spring and summer months. During the autumn and winter, however, longer periods between grazing are necessary.

7. The following seed mixtures can be recommended for the irrigation areas:

(a) New areas where no irrigated pasture existed previously—

Paspalum dilatatum	8 lbs. per acre.
New Zealand Certified White Clover	2 lbs. per acre.

(b) Where some irrigated pasture already existed—

Certified Perennial Ryegrass	4 lbs. per acre.
Paspalum dilatatum	4 lbs. per acre.
New Zealand Certified White Clover	2 lbs. per acre.
or	
Certified Perennial Ryegrass	6 lbs. per acre.
Certified Akaroa Cocksfoot	4 lbs. per acre.
New Zealand Certified White Clover	2 lbs. per acre.

8. *Phalaris tuberosa* and White Clover associate well under irrigated conditions, providing rotational grazing is efficiently managed. A period of at least 20 days in the flush season is required between grazings.

9. A mixture of Cocksfoot and White Clover is proving successful under existing conditions. It is now recommended that Cocksfoot could be added to Perennial Ryegrass and White Clover for the establishment of an irrigated pasture.

10. Perennial Ryegrass and Cocksfoot association with Paspalum and White Clover appears to assist in preventing matting of the pasture, thereby assisting in maintaining a relatively prolific sward.

11. Surface renovation is essential on Paspalum pastures to maintain an adequate proportion of clover growth. Chain and pasture harrows should be used annually during the winter months, to prevent rank growth appearing in patches.

Blackberry Eradication.

By H. Tarlton Phillips.

INTRODUCTION.

The use of chemicals for weed killing purposes has received considerable prominence and attention during the last few years, and the article by Mr. H. Tarlton Phillipps details his experiences with chemicals, particularly sodium arsenite, for treating blackberries on his Balingup property.

It must be pointed out that the opinions expressed by Mr. Phillipps, in the course of his article, are his own personal opinions and do not necessarily represent those of the Weeds Committee.

Experiments mainly carried out in New Zealand and the Eastern States have shown that sodium chlorate and arsenical compounds including sodium arsenite and arsenic pentoxide are, in general, the most effective chemical weed killers. One decided disadvantage of arsenical preparations, is the danger of poisoning animals and this aspect has greatly reduced their use. Again sodium chlorate is inflammable, but certain proprietary lines have been manufactured to assist in overcoming this defect.

The Weeds Committee appreciates the fact that chemicals will play their part in blackberry control, particularly on roadsides, but stresses the possibilities of cultivation and pasture establishment associated with judicious management. Killing blackberries with sprays is naturally a costly process as not only must the cost of materials beincluded, but also that of plant and labour.

Experiments organised by the Weeds Committee at present in progress in the Bridgetown-Balingup district have been designed to compare the effects and costs of different concentrations of various chemicals and weed killing preparations, and also the results of certain cultural measures associated with pasture establishment. Included among the chemical applications is the sodium arsenite treatment found so effective by Mr. Phillipps and detailed in this article.

In an article on Blackberry Eradication, which has recently appeared in the Press, it is stated that extensive experiments in Victoria have shown that blackberries cannot be eradicated by spraying alone, and that success can only be attained where spraying is used in conjunction with cutting, cultivation, etc.

Systematic spraying on my Balingup property, extending over the last three years, has demonstrated, beyond any possibility of doubt, that blackberries can be eradicated by spraying, combined with burning, with absolute certainty, and at a small cost, even when they are growing under the most favourable conditions.

The explanation of this apparent anomaly is probably to be found in the fact that, in the blackberry infested districts of the Eastern States, there is, in most cases, a comparatively heavy rainfall during the Spring and Summer months. This would considerably increase spraying difficulties and also the vigor of the plants, during the growing season. Whether this be the case or not, it may be taken that, under conditions existing in the South-West corner of West Australia spraying is completely effective, provided that it is carried out systematically and at the proper times.

The country dealt with here consisted of about a mile of flats, along the Balingup Brook, infested with blackberries throughout, including some brambles about fifteen feet in height, which covered individually considerable areas, in addition to odd brambles growing on the hillsides and elsewhere.

The treatment applied consisted in cleaning up all titree and undergrowth along the brook, in order to give easy access to the brambles, which were then sprayed with a solution of Sodium Arsenite during the Spring and Summer months. In the case of the larger brambles, it was only found possible to spray around the margins. This, however, provided sufficient dead wood to enable a

fairly good burn to be obtained in the Autumn. It is most necessary, when starting on a bramble for the first time, to get it cleaned off level with the ground as soon as possible, in order to facilitate spraying and reduce the amount of solution required to a minimum.

In our spraying operations both Atlacide and Sodium Arsenite have been used, and we have demonstrated that blackberries can be completely destroyed by either. The arsenical solution appears to have given slightly better results. It is very cheap, and brambles burn fiercely after its application. It is also poisonous and must be used with reasonable care. The cost of Atlacide is prohibitive for extensive spraying, though it may, in some cases, be used advantageously in conjunction with the arsenic, as described later.

Sodium Arsenite solution is prepared by mixing 1 lb. of White Arsenic (Arsenious Oxide) with ½ lb. Caustic soda. The "flaked" variety of the latter is the most convenient. These amounts should be weighed and mixed dry. About an equal volume of water is then added and the mixture stirred. In about a minute it will boil violently, the solids being dissolved almost immediately. When solution is almost complete, further water may be added to make up to four gallons. If too much water be added at first, the temperature will not become sufficiently high to cause boiling and it will take longer to make up the solution.

This mixture, viz. 1 lb. Arsenic, ½ lb. Caustic Soda, and 4 gallons of water may be taken as the standard strength solution, as recommended by the Agricultural Department for spraying purposes, or for killing trees. We find that better results are obtained by using one quarter of this strength. In addition to reducing the spraying costs, and also the danger of poisoning stock, the time required to kill the blackberry is increased to about four or five days, allowing more time for the poison to be carried down to the roots. If blackberries are sprayed with this solution when the fruit is ripe, there is a definite risk that children might be poisoned as a result of eating the fruit within the next couple of days, before the plant begins to die.

Our spraying, throughout the whole of last season, was carried out with a barrel sprayer, containing 40 gallons, carried in a cart and fitted with 50 feet of ½ inch hose.

This length of hose is a great convenience and enables many bushes to be reached which otherwise would be out of range. A jet of the Spray Pistol type, or one with a trigger release, fitted with a three foot extension, is to be recommended, as it is essential that it should be possible to turn off the jet instantly to avoid spraying the grass. There should be no leaks from the jet, for the same reason, also the slight excess of Caustic Soda in the solution has a bad effect on the hands, and rubber gloves may be worn with advantage.

The solution recommended consists of 2½ lbs. Arsenic, 1¼ lb. Caustic Soda to 40 gallons of water. This gave excellent results provided that the work was done thoroughly with a good pressure, the rather weak solution increasing the time of dying and thus left more time for the poison to be carried down to the roots. At present prices the cost of materials is as follows:—1 cwt. arsenic, 45s.; ½ cwt. caustic soda, 29s. 7d.; Sales tax, 4s. 6d.; railage to Balingup, 150 miles, 8s. 3d. (No doubt exemption from sales tax could be obtained for this purpose). On these figures the cost of the spraying solution would work out at 1s. 11¼d. per 40 gallon cask.

The methods adopted by us during the last three years have varied somewhat in the light of experience and will no doubt be subject to further modification. Pending further information, the procedure recommended may be followed

with absolute certainty of success, provided that it is carried out in its entirety and spraying operations are carried out thoroughly and at the proper time.

When a start is being made on an untreated bramble, the method adopted will vary according to whether or not it is too large to spray completely. As already mentioned, where this is not possible, the margins should be sprayed towards the end of summer in order that a good burn may be obtained in Autumn. Where it is possible to spray the whole bramble, we have obtained very good results by spraying for the first time about the end of October. A fairly clean burn can then usually be obtained towards the end of November without burning the country. When the re-growth is about 1 foot or 18 inches in height, spray again. Repeat the process when the second re-growth is about the same height. Towards Autumn, there will probably be a third re-growth. This will not be strong, and if it be not allowed to develop too much, there will be sufficient dry Blackberry to enable a very clean burn to be obtained, which will destroy the third re-growth.

The ground will now remain virtually bare during the winter. By the following November a definitely weak re-growth will occur, but in most cases, anything from 50 per cent. to 75 per cent. of the original roots will be dead, and the growing plants will be separated by considerable spaces. These should be sprayed as in the previous year, and again burnt off at the end of the season, if possible. Probably they will be too far apart. In the third year the bramble will be virtually dead, though a little spotting may be necessary.

No general rule for spraying can be given, since individual brambles vary greatly in vitality. In some cases, one spraying will kill them, and in others it may take two or even three years. In no case should the re-growth ever be allowed to get more than 12 or 18 inches in height or to develop runners. It is useless to start on a bramble and to fail to spray at the correct time, since the roots soon recover their original vigour, if spraying is neglected.

It might, at first sight, appear that the above treatment is a full time job. In practice, after the first spraying and burn, the amount of time and solution required are surprisingly small and a very large area can be covered at a small cost, both as regards time and material.

Sodium arsenite is poisonous to stock, if sprayed on grass. With care, this risk can be reduced to a minimum. The writer has not had experience with sheep in this connection. Cattle do not appear to eat sprayed brambles, though it is wise to keep them away for a few days after spraying, while the brambles are dying. The risk with large brambles appears to be very small. There is however, a slight risk in the case of small plants a few inches across, growing in grass, since a considerable amount of spray must go on the grass surrounding them.

It has been shown that the amount of white arsenic necessary to kill a beast, varies from 225 to 700 grains. A solution of the strength recommended for blackberry spraying contains 1 oz. or 437 grains of arsenious oxide per gallon, and it will therefore be evident that it would be necessary for a large amount of sprayed grass to be eaten to produce lethal effects.

The writer recently sprayed 115 seedlings, from 6 inches to 12 inches across, growing in green grass about 6 inches in height on an area of 270 square yards, with the above solution. All this grass was eaten by several head of cattle a few days later, without any symptoms of poisoning being apparent. At the same time, poisoning might possibly occur in certain cases. Since only 75 grains of arsenious oxide are necessary to poison a sheep, the risk in that case might be greater. It will be noted that the figures given refer to white arsenic and not to

sodium arsenite, the toxic effects of which may be somewhat different. They will however, serve to give some idea as to the risk.

Large areas of badly infested country may be temporarily fenced off, where this can conveniently be done. It should also be borne in mind that, after one or more sprayings and a burn, the sprayed area remains bare, apart from any re-growth of blackberries. When this occurs, the area may be safely sprayed with arsenic, grassy margins and small isolated plants being subsequently done with Atlicide, which is not poisonous. We have found this procedure satisfactory. Spraying carried out on the lines laid down, will be found successful in all cases.

The blackberry grows mainly in temperate countries, being most troublesome where summer rains are experienced or where soils are naturally moist during the warm season.

The method of attack should be to spray, as far as possible, and, at all costs prevent it from seeding, which can easily be done by burning. At present practically the only agent in the distribution of the seed is the Silver Eye, which does not appear to travel any great distance from its source of food, and in consequence, to distribute the seed over any great area. If, at any time, the Starling and Sparrow, both of which are numerous in South Australia, should obtain a footing in this State, the blackberry within a year or two might become universal throughout the South-West. Let us therefore deal with it while it can be done easily, and before it is too late.

A curious and unexpected feature of this Arsenical Spray is that it does not appear to have any permanent ill-effect on the land. Areas of our flats, which, three years ago were so thickly covered with brambles that it was impossible to walk through them, are now densely coated with Paspalum, which attained an average height of about three feet last season, in spite of the land having been subject to numerous arsenical sprayings during the preceding two or three years. Paspalum and Kikuyu grass form an excellent insurance against re-infection with blackberries, which appear to be unable to establish themselves on land well covered by these grasses.

In conclusion I would again urge everybody to take the problem in hand, and at least, to prevent any further seeding. In our own case, the position appeared virtually hopeless, but in the space of three years we were able in practice to clear up half the property and get the remainder under complete control, with a very small expenditure of time and money and the certainty that, within a comparatively short time, the last blackberry on the property will have been finally destroyed.

Tubercle-Free Herds.

The following herds have been declared free from tuberculosis in accordance with the requirements of the Scheme for the certifying of herds tubercle-free, and unless otherwise declared the certificate remains in force until the date shown in respect of each herd:—

No.	Owner.	No. of Cattle Tested.	Date of Expiry.
1	A. Groves, Toodyay and Wagerup	187	1940. 31st December.
2	School of Agriculture, Narrogin	38	do.

Fertilisers—Additional Registrations.

The last December issue of this Journal contains a list of the fertilisers registered for the current fertiliser year, together with the minimum percentages of the fertilising ingredients. Additional registrations, with the respective analyses, are shown in the following table :—

Name of Fertiliser.	Reg No.	Brand.	By whom Registered.	Nitrogen (N_2) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on rails at Perth.
				Nitrate.	Ammonia.	Blood and Bone	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
Nitrate of Soda	135	Champion	A. Hicks	16·0	....	....	....	....	....	....	....	....	....	‡16 0 0
Kainit	136	"Stork"	Westralian Farmers, Ltd.	....	....	....	....	....	....	....	....	....	14·0	*
Sulphate of Potash	137	do.	do. do.	....	....	....	....	....	....	....	....	48·6	....	*
Potash Manure Salts	138	do.	do. do.	....	....	....	....	....	....	....	....	....	30·0	*
Muriate of Potash	139	do.	do. do.	....	....	....	....	....	....	....	....	....	50·0	*
Phosphatic Guano	140	"Cormo"	M. F. Phillips	....	....	....	2·2	....	....	22·0	22·0	....	....	†5 2 6
Fish Fertiliser	141	do.	do. do.	....	....	5·0	....	....	....	8·0	8·0	....	....	†9 12 6
Batsos—The Complete Fertiliser	142	Batsos	Chemtek (W.A.)	....	....	....	1·0	1·25	1·0	1·75	4·0	....	....	*

* Price on application. † Price at Works. ‡ Price on Rail at Fremantle.

COMMONWEALTH OF AUSTRALIA.

Dissemination of Meteorological Information.

Under the restrictions imposed by the Censorship on the broadcasting and dissemination of weather information, it was necessary to devise a system whereby reports and forecasts could be made available to pastoralists and others for whom they are an economic necessity. Arrangements were effected at the Central Administration and at Divisional offices of the Commonwealth Meteorological Branch for the issue of district forecasts for country areas throughout each State to be furnished to all telegraphic offices at 12 noon daily. Although the restrictions have recently been lifted the service is still in force and interested parties desiring the forecasts for a district are advised to apply by telephone or reply-paid telegram to their local postmaster, or, if more convenient, to the Weather Bureau, Perth, Telephones Nos. B4599 or B4990. The information is also displayed on Post Office notice boards.

Butter: Its Composition and Deterioration.

H. H. Kretchmar, Dairy Bacteriologist.

SYNOPSIS.

In the following paper an attempt has been made to survey the present state of knowledge concerning the composition of butter and the course of its deterioration. It will not be possible to present the whole of this material in the present issue of the Journal; the paper will be completed in the next issue.

Because of their fairly general use in research work the first section discusses the present methods of grading butter. The difficulties of grading the material by the senses of taste and smell are explained and possible methods of more scientific value are considered.

Since salt and acidity affect the flavour of butter, the next two sections of the paper deal with this matter. As a logical deduction the writer shows that some of the experiments mentioned in the literature, and later quoted, are unsound because this aspect of the problem has been neglected; in other words, more than the one factor being specially studied has influenced the experiments, and these other factors, salt and acidity, have a definite influence upon flavour.

The influence of various controllable factors upon the deterioration of butter is next discussed. Data is quoted to show the effect of acidity upon keeping quality when the material is held in cold storage, and also when the material is held at room temperatures. The two sets of data, taken conjointly, indicate that the acidity for best keeping quality is independent of storage conditions. The acidity for optimum keeping quality is pH 6.7 — 6.9.

Data is quoted to show the effect of copper and iron impurities in accelerating the rate of decomposition. The probable influence of acidity in controlling the effect of these substances is mentioned.

The effect of the temperature of storage on the rate of deterioration is next considered. Data is quoted to show that when factors which cause decomposition are operating, small changes of temperature, even when such temperatures are low, caused marked increases in the rate of deterioration.

A section dealing with the gas content of butter shows that 100 gms. butter contains about 4-5 ccs. of gas. The writer has given a simple calculation to show that the greater part of this gas is not dissolved in the serum but is dispersed throughout the mass of the butter as small gas bubbles. Because of its fine state of division the gas presents a very large surface of contact with the butterfat, an ideal condition to cause oxidation of the fat when the gas contains oxygen. In the following section data is quoted to show that at 0°F. little oxygen is absorbed, but, at 32°F. oxygen is absorbed comparatively rapidly.

A section is devoted to the composition of butterfat. It is shown that the composition is variable, being influenced by the seasons and the feeding of the animals. A particularly important analytical constant of the fat is the iodine value, for this gives a measure of the percentage of unsaturated materials present, materials which are readily oxidised and which, because of their low melting-point cause softness of the butter. The Reichart-Meissl value is also of some importance as a measure of material influencing the hardness of fat, and is a measure of those substances which, upon hydrolysis, may give rise to substances having objectionable odours and flavours. The question of the odours of the lower fatty acids is discussed.

The problem of butterfat oxidation is considered from various aspects. In the first place the writer has noted that probably no experiments have been made on the oxidation of pure butterfat. When other materials are present with the glycerides, as is the case with the fat phase as usually obtained from butter, and more particularly when butter itself, or milk is being examined, some of these materials are oxidised, or partially oxidised, in preference to the glycerides. The course of the oxidation is probably different in butter to that in the separated fat phase, and quite likely differs at elevated and at low temperatures.

The nature of the oxidation change is indicated and the aromas and flavours of oxidation products considered. Many of the chief oxidation products have marked odours. The odour of rancidity is certainly not due to butyric acid but is perhaps due to heptylic aldehyde. The "oxidised flavour" of milk is probably due to a lecithin decomposition product.

Reference is made to the substance responsible for the development of the pink colour in the Kreis test for rancidity. The substance responsible for the odour of rancidity is not the same substance as causes the development of the colour in the Kreis test.

In the next section data is quoted to show the extent of the correlation between the analytical figures for the extent of fat oxidation and the fall in grade. The writer notes that deterioration of butter is not due to any one factor but to a number of factors. Consequently, all that can be expected regarding any analytical data for particular types of decomposition is that, when a particular type has proceeded to a certain extent, as measured by the analytical method, the grade must be below a certain level. Samples in which the type of decomposition being investigated has not proceeded to the extent expected to bring the material into the grade noted, have dropped into that grade because of other types of decomposition.

In the section devoted to the influence of various factors upon the rate of oxidation it is shown that acidity of the butter serum, the presence of copper and

iron contaminants, and exposure to light are particularly important. Exposure to light is probably an essential factor in the development of rancidity. This section is concluded with a discussion of the various protective wrapping materials.

Passing on to the next class of substances the decomposition of which gives rise to undesirable products, the composition of the proteins, casein and lactalbumin, so far as known, is given. The writer points out that hydrolysis alone produces material undesirable from the standpoint of flavour. The conditions governing the further breakdown of the proteins are discussed. It is shown that, neglecting feed taints, the quality of cream for buttermaking may probably be assessed on the percentage breakdown of the protein matter into amino-acids.

The important phospholipid fraction is discussed in the next section. The writer points out how this substance is probably responsible for the stabilisation of the milk emulsion, an assumption which explains well a number of facts concerning butter and its deterioration. Work which shows that lecithin decomposition is probably the main cause of the development of fishy odours in butter is reviewed. Other probable causes of fishy defects noted in the literature are the absorption of fishy odours from other materials stored near the butter, and, in the case of milk, the excretion of trimethylamine oxide in the milk by cows fed on beet waste. The writer shows that a series of observations noted in the literature lead to the conclusion that feeding linseed cake may also cause the defect in butter.

Experiments connected with the factors concerned in the development of fishiness are noted in detail. It is noted that salt and acidity, in the absence of other factors, do not cause fishiness. This is important because of the effect of salt, noted later, in restraining microbial growth. The necessary agents for the development of fishiness appear to be oxidation promoters such as metal contaminants or microbial enzymes. In the presence of such factors, salt and acidity accelerate the appearance of the defect.

The second part of the paper deals mainly with the role of microbiological agents in causing deterioration. The initial section discusses the limitations of the various methods used for examination. Later it is pointed out that, taking into consideration all the conditions of the experiments, but little reliable data is available regarding the effect of any single controlling factor on the growth of any one type of organism.

In the section dealing with the growth of moulds in butter, the data quoted indicates that a very considerable controlling influence is exerted by salt. Temperature, humidity and the degree of exposure to air are important growth-controlling factors.

Salt also exerts a considerable controlling influence on the growth of bacteria in butter. The available evidence indicates that the concentration of the salt in the serum should not be allowed to fall below about 10.5%, equivalent to 1.7% salt in butter containing 16% moisture. Consistent with the finding that salt inhibits the growth of bacteria in butter when the temperature is favourable for growth (as is usually the case after sale) is the finding that salt increases the keeping quality of butter in these circumstances.

A limited correlation has been noted by various workers between the microscopical picture and the keeping quality of butter at temperatures near room temperature.

The writer has not noted any work which indicates any correlation between bacterial types, determined by plating methods, and keeping quality. In view of the fact that the nature of the odour of all the lower fatty acids is still doubtful,

and most likely not pronounced in the case of any of the substances, the writer would draw attention to the fact that this problem needs investigation before any work is continued with the lipolytic organisms. In view of the fact, which he has pointed out earlier in the paper, that hydrolysis of the proteins certainly gives rise to at least one substance with a strong flavour, proteolytic species are important. However, proposed tests for proteolytic species afford no indication as to whether degradation further than hydrolysis will be produced by the species and thus give no indication regarding the extent to which proteolytic species are undesirable.

The writer has also drawn attention to the fact that the proposed tests for undesirable species are unsatisfactory in that they give no evidence of the numbers of organisms capable of growing in the conditions obtaining in butter.

The data published indicates that salt has a marked controlling effect on the growth of yeasts in butter, but the evidence available is insufficient to indicate whether this type of organism is of importance in causing deterioration.

BUTTER GRADING.

Any person with scientific training reading through the literature will realise that the number of grade points assigned to a sample of butter is, with the present systems of grading, dependent upon a number of quite unconnected factors. Consequently, such systems of grading form unreliable methods for the study of any one particular type of deterioration. Let us consider the system used locally: 100 points are allowed for the perfect sample of butter. Of these points 50 are allotted for flavour and aroma, 30 for body and texture, and 20 for condition, which term includes colour, salting, packing and package.

Samples graded 93 to 100 points inclusive are choice grade butter—90 to 92 inclusive are first grade—86 to 89 inclusive are second grade, and 83 to 85 inclusive are pastry grade. In other words, although 100 points are allotted for scoring purposes, not more than 20 are utilised to cover all grades.

The alteration in grade due to flavour and aroma defects is as follows: Butter perfectly neutral in flavour and aroma or possessing no undesirable flavour and aroma is classed as choice grade. Samples with a slight volatile feed taint are also included in choice grade, as this defect is said, in general, to pass off on keeping. With more definite feed taint, or slightly unclean or metallic flavour the butter is classed first grade. An increased intensity of the defects puts the butter in second grade. Advanced defects place the butter in the pastry grade.

The senses of colour-vision, taste and smell differ in acuity from one individual to another, and in the same individual from one time to another. In the section of this paper dealing with the effect of salt upon flavour is a table which illustrates how even experienced butter judges differ in their opinions. In this particular table it will be noted that judge No. 2 detected a fishy flavour in 15 samples whereas judge No. 5 noted the defect in only 7 of the same batch of samples. In consequence of the variation in the senses, defects noted by them form very poor criteria by which to judge the nature and extent of any change in dairy products. Undoubtedly, the general concensus of opinion resulting from the use of these senses must form the criteria by which the desirability or otherwise of a given change in any food product is judged. However, as these sensory impressions are not, in our present state of knowledge, susceptible of measurement, it is much more desirable for scientific purposes

to measure chemical changes which, in many cases, we can measure with a fair degree of accuracy and, in addition, obtain a general opinion regarding the effects produced on the senses by such changes which have proceeded to varying extents, the variation being measured by the chemical method.

The senses of taste and smell are often fallible in their judgment for the simple reason that many substances taste or smell similarly. Sugar, saccharin and lead acetate are all sweet, yet they have no chemical similarity. Again, substances similar chemically may have quite different odours; for example formaldehyde, HCHO, and acetaldehyde, CH_3CHO, or anisaldehyde,

$$C_6H_4 : \begin{matrix} OCH_3\ (1) \\ CHO\ (4) \end{matrix}$$

and vanillin, $C_6H_3 : \begin{matrix} OH\ (1) \\ OCH_3\ (2) \\ CHO\ (4) \end{matrix}$

In some cases, substances which have first been considered to possess a typical smell, have later been shown to possess no smell, the smell originally associated with the substances being actually due to minute traces of impurity. A well-known case is the mousy smell associated with acetamide as it is usually obtained.

Probably the greatest difficulty associated with judgment dependent upon taste and smell is occasioned by the fact that substances present in only minute quantities may be involved; in fact, when present in large quantities substances often produce entirely different sensations to those which they produce when present in small concentrations.

A survey of the literature makes it evident that many of the changes causing deterioration of butter may be studied, to some extent at least, by accurate chemical methods.

A number of workers have attempted to correlate the grade of butter and/or cream with various products of decomposition. In general, these studies have not been productive of very satisfactory results. This is only to be expected, because the fall in grade of butter is not due to any one type of decomposition but to a number of frequently unconnected factors. What is to be expected, however, is that when any type of decomposition has proceeded beyond a certain point there will be a notable fall in grade. In the cases of the main types of decomposition, such as protein hydrolysis and fat oxidation, it will be shown in the following pages that the changes may be followed chemically, and that chemical evidence gives satisfactory indications as to whether or not further decomposition in a particular manner will cause marked changes of grade.

THE EFFECT OF SALT ON THE FLAVOUR OF BUTTER.

When the effect of salt upon the keeping quality of butter is studied a further effect of salt should also be taken into consideration. This is the effect of salt upon flavour. As the cook and the epicure well recognise, salt heightens the flavour of most food. Butter is no exception to this generalisation. Hunziker says (4) :— "Yet it is a fact that salt possesses the tendency of hiding or destroying the delicate flavour and aroma and of intensifying objectionable flavours. Butter with a high salt content (above 3 per cent) usually lacks the fine and delicate flavour which is characteristic of prize-winning butter. Nor does high salt content cover up bad flavours as is popularly believed. such flavours are made more prominent by the

salty taste. The salt does not hide them and gives the butter a disagreeable coarse character. In fact, butter made from second grade cream is more palatable and sells to better advantage when not salted at all."

The effect of salt in bringing out the flavour of butter is well shown by the following data taken from a paper by Washburn & Dahlberg (5):—

Churn No.	Salt.	Score.	Judge's Comments.
3	% 0	93·00	Good.
	1·72	93·25	Will not go fishy.
2	0	91·00	Good.
	2·07	91·25	Tendency to fishy.
6	0	94·25	
	2·41	94·00	
1	0	91·75	Dry.
	2·51	90·75	Tendency to fishy.
4	0	92·50	Good.
	3·27	92·50	Good.
5	0	95·00	Extra fine aroma.
	3·79	92·75	

Half of the butter of each churning was salted and worked, and the other half worked unsalted.

It will be noted that in the case of churnings 3, 6 and 4, where the score of the unsalted butter is high, the score of the salted butter is practically identical. In the case of churning No. 1, where the score of the unsalted butter is lower, the salt has apparently brought out the undesirable odour and flavour. In the case of churning No. 2, the salt has brought out a suspicion of an off-odour and flavour. The salting was lighter than in the case of churning No. 1. As regards churning No. 5, the very high percentage of salt may have spoilt the odour and flavour or, what is more likely, have brought out a slight taint. Washburn and Dahlberg have not noted the effect of salt in enhancing flavour and odour in butter.

Whilst experimenting with the effect produced on odour and flavour by the addition of various substances to butter, Supplee noted that, in general, flavour and odour defects were more noticeable in the salted portion of a sample than in the unsalted portion (6). He said:—"The greater number of positive comments from the salted butter is also worthy of note, and, from what is generally known regarding the occurrence of the fishy flavour in such butter, it might tend to strengthen the trimethylamine theory of this flavour." The following table is selected from Supplee's paper because the experiments were made with butter having a lower acidity than in any other series reported, and further, the substances were added directly to the butter.

EFFECT ON THE FLAVOUR OF BUTTER MADE FROM PASTEURISED SWEET CREAM WITH 0·16 PER CENT ACID OF WORKING TRIMETHYLAMINE AND FATTY ACIDS DIRECTLY INTO THE BUTTER AT THE RATE OF 85 PARTS PER MILLION.

Sample.	Material Added.	Comments by Judges.					
		No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
ES	Nothing	...	...	...	...	...	...
E	Nothing	...	...	...	...	...	...
1ES	Trimethylamine ...	Fishy	Fishy	Fishy	Fishy	...	Fishy
1E		Fishy	Fishy	...	...	...	Fishy
2ES	Trimethylamine-lactate	Fishy	Fishy	Fishy	Fishy	...	Fishy
2E		...	Fishy	..	...	...	Fishy
3ES	Trimethylamine-butyrate	Fishy	Fishy	Fishy	Fishy	Fishy	Fishy
3E		...	Fishy	...	...	...	Fishy
4ES	Trimethylamine-oleate	Fishy	Fishy	...	...	...	...
4E		...	Fishy	...	...	...	Fishy
5ES	Trimethylamine-stearate	...	Fishy	...	Fishy	...	Fishy
5E		...	Oily	Fishy	Fishy	Fishy	Fishy
6ES	Trimethylamine and soluble fatty acids	Fishy	Fishy	Fishy	Fishy	Fishy	Fishy
6E		...	Fishy	Fishy	Fishy	...	...
7ES	Trimethylamine and insoluble fatty acids	Fishy	Fishy	...	...	Fishy	...
7E		...	Fishy	...	...	Fishy	...
8ES	Lactic acid ...	...	Fishy	...	...	...	...
8E		...	Fishy	...	...	...	...
9ES	Butyric acid ...	Fishy	...	Fishy	...	...	Fishy
9E		Fishy	...	Fishy	Fishy	Fishy	...
10ES	Oleic acid	...	...	...	Fishy	...	...
10E		...	...	...	Fishy	...	...
11ES	Soluble fatty acids	...	...	...	Fishy	...	...
11E		...	...	...	...	Fishy	...
12ES	Insoluble fatty acids	Oily	...	...	...	...	Oily
12E		Oily	...	...	...	...	...

(S following sample number indicates salted butter.)

The above table brings out very well the difference in the reactions of various judges to the same sample of butter. Whereas judge No. 2 noted a fishy defect in the case of 15 samples, judge No. 5 noted the defect in only 7 of the same samples.

THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE FLAVOUR OF BUTTER.

The effect of acidity upon the flavour of butter is mentioned by Hunziker in his work "The Butter Industry" (4). Hunziker says: ". . . . . the delicate flavour and aroma characteristic of good butter are intimately related to the acids in the cream. When neutralising to a point sufficiently low to destroy practically all the acid, the delicate butter flavour usually also suffers and the resulting butter is flat and tasteless."

Hunziker's observation of the effect of neutralisation affecting the flavour is certainly correct, but, by destruction of the acid he obviously means neutralisation of the acid, and, in view of the facts that the desirable aroma of fine quality butter is generally considered to be due to the substance diacetyl and that the lower fatty acids are generally considered to have undesirable aromas, his implication that the desirable aroma is bound up with the presence of free acids seems open to question. The question of the aroma of the free fatty acids will be discussed later.

The following table, showing groups of samples arranged in order of hydrogen-ion concentration with the corresponding flavour scores, was reported by Gilmour (7).

pH Value of Butter in the Group.	No. of Samples.	Average pH Value of Group.	Variation of Individual Flavour Scores in Group.	Average Flavour Score of Group.
7·40 and over	58	7·47	168—172	170·52
7·30 and under 7·40	61	7·32	165—174	170·51
7·20 „ „ 7·30	118	7·22	165—173	170·30
7·10 „ „ 7·20	130	7·13	159—174	170·05
7·00 „ „ 7·10	156	7·02	164—173	170·08
6·90 „ „ 7·00	184	6·93	159—172	170·07
6·80 „ „ 6·90	165	6·83	162—173	169·79
6·70 „ „ 6·80	142	6·72	158—174	169·54
6·60 „ „ 6·70	133	6·63	159—172	169·26
6·50 „ „ 6·60	74	6·53	159—172	168·77
6·40 „ „ 6·50	39	6·43	148—172	167·08
<6·40	32	6·20	159—171	167·16

Gilmour commented on the above results in his summary as follows: "On correlating the pH values and the flavour scores, it was found that there was a decided tendency for the flavour score to diminish as the acidity increased—*i.e.*, as the pH value decreased."

The writer has noted a similar tendency in the case of West Australian butters (8). The following table is taken from his paper:—

pH Values.	Grade initially.			
	93	92	91	90
	%	%	%	%
>7·2	33·3	13·9	...	3·8
7·1—7·2	20·8	2·8	6·2	...
7·0—7·1	8·3	5·5	8·6	5·8
6·9—7·0	12·5	8·3	6·2	9·6
6·8—6·9	...	8·3	11·1	11·5
6·7—6·8	...	16·6	16·0	32·7
<6·7	25·0	44·4	51·9	36·5

From these results the writer concluded: ". . . . . there is quite a marked correlation between the initial flavour score and the pH values, the butters with the higher flavour scores being generally less acid than those with lower flavour scores. . . . . .

"Two points should be noted in this connection:—

(i) Is the selection of these nearly neutral, or even slightly alkaline butters due to the training of the graders to prefer this type? *or,*

(ii) Have they been chosen as the best quality material because, in neutral materials, as contrasted with acid materials, any off-flavours would not be sufficiently noticeable to command attention? . . . .

"The possibility of undesirable odours and flavours being present but masked because of the neutral condition of the material deserves investigation."

THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE KEEPING QUALITY OF BUTTER.

Of all the factors studied, hydrogen-ion concentration appears to have the greatest influence on the keeping quality of butter.

Arup & Gilmour noted the controlling influence of hydrogen-ion concentration upon the keeping quality of butter (9). "Altogether, out of the 72 boxes stored only 12 depreciated in flavour by more than 2 points; of these 10 had pH below 6.7, one had pH 6.7 and one had a pH above 6.7. Further, out of the 72 boxes only four fell below export quality, and all these had low pH values. Remembering that but one-third of the butters had pH values below 6.7, the number with low pH that depreciated appreciably in flavour was out of all proportion to the depreciation of those with high pH. In agreement with this is the well-known fact that starter butters do not store so well as those made from fresh cream. This is possibly merely a more exaggerated case than the present one of pH difference.

"The conclusion arrived at is that when butter is to be cold stored, only lots of high pH should be selected."

Loftus and Hills *et alia* in their study of the factors affecting the keeping quality of butter noted the effect of hydrogen-ion concentration (10). "With the exception of the erratic result for the one butter in the pH range 5.0—5.5 there is a distinct association between pH and change of grade." Sixty-five samples were examined. The samples were stored at 12°F. for three months.

The writer examined the influence of hydrogen-ion concentration on the keeping quality of 236 churnings of butter made commercially and stored in a commercial cold store during the 1937-38 storage season (8). In storage the temperature was maintained around 10°F. The storage time varied from six to fifteen weeks, the greater number of samples being stored from eight to eleven weeks. The following table shows the percentage of samples in each pH range which fell a given number of points in score:—

Fall in Grade (pts.).	pH Values.											
	<6·2	6·2-6·3	6·3-6·4	6·4-6·5	6·5-6·6	6·6-6·7	6·7-6·8	6·8-6·9	6·9-7·0	7·0-7·1	7·1-7·2	>7·2
3 ...	50·0	12·5	...	6·6	3·7	3·6	...	4·0	...	...	7·1	7·1
2½ ...	...	...	...	...	...	...	...	...	...	...	...	14·3
2 ...	50·0	12·5	20·0	10·0	14·8	10·7	2·6	...	26·3	15·4	42·9	35·7
1½ ...	...	12·5	...	...	11·1	3·6	5·1	4·0	...	...	...	21·4
1 ...	...	25·0	20·0	33·3	18·5	39·3	41·0	20·0	31·6	30·8	21·4	21·4
½ ...	...	37·5	40·0	26·6	33·3	25·0	2·6	44·0	10·5	38·5	14·3	...
0 ...	...	...	20·0	23·3	18·5	17·9	48·7	28·0	31·6	15·4	14·3	...
Average fall	2·5	1·2	0·8	0·9	0·9	0·6	0·5	0·6	0·9	0·8	1·4	1·8

NOTE: Owing to the very small number of samples which had a pH value of 6.2 or lower, no great importance should be attached to the figures in the first column of the table.

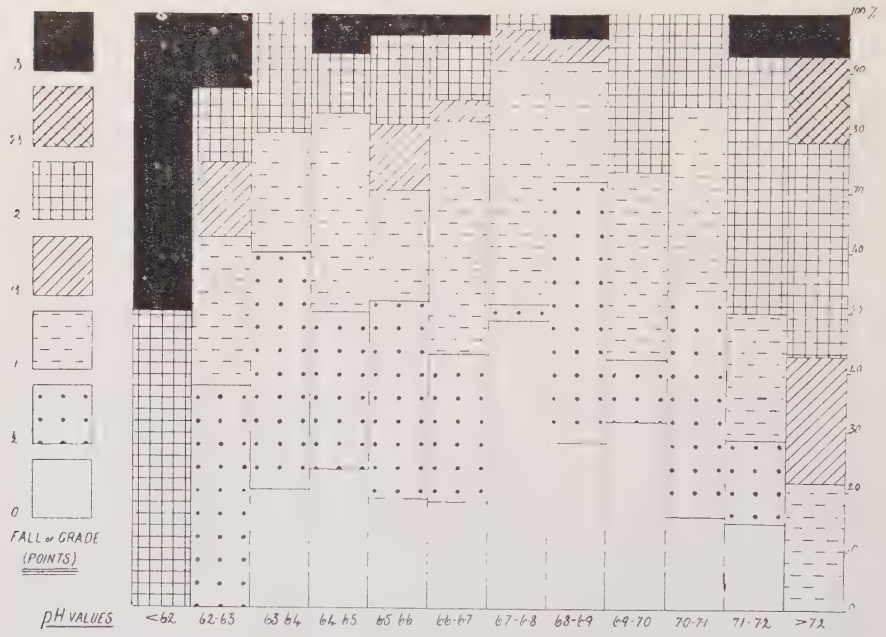
The writer concluded: "There is a marked correlation between the keeping quality in cold store and pH values. The optimum acidity for keeping quality is about pH 6.7 — 6.9." The results tabulated above are shown graphically on page 102. The butter is classed according to the number of grade points by which it deteriorated.

The writer made similar tests during the 1938-39 storage season, selecting for examination the samples which just fell in the first grade class, i.e. 91 score. The results obtained amply verified the above findings, the samples within the pH range of 6.7 — 6.9 again showing best keeping quality.

Similar findings to those of the writer are mentioned in America by Parsons (11). Five thousand samples of butter kept at 70°F. for eight days only lost on an average 1 point in score when the pH value of the fresh butter was 6.6 to 7.0, and 0.5 point when the pH value was 6.7.

It is very interesting to compare the writer's results with those reported by Parsons. The writer's experiment was made with butter samples held in cold store. Parsons reports that his samples were stored at 70°F. As the pH value for optimum keeping quality was the same in both experiments, this indicates that it is independent of the temperature of storage.

GRAPH SHOWING CORRELATION BETWEEN pH VALUES AND KEEPING QUALITY.



THE EFFECT OF IRON AND COPPER ON THE KEEPING QUALITY OF BUTTER.

Owing to the fact that milk contains copper and iron in traces, one would expect traces of these metals in even the best quality butter. Williams gives the following data (12).

Superfine butter—Copper 0.2—0.25 p.p.m.
Iron 0.5—1.00 p.p.m.

Second Grade — Copper normal.
Iron 1.2—1.7 p.p.m.

Carefully designed experiments were made by Rogers *et alia* to determine the effect of iron on the keeping quality of butter (13). The butter samples were made from pasteurised ripened cream which had been carefully selected as having come in contact with no vessels except such as were well tinned. In each test the cream was divided into two portions after pasteurisation and to one portion ferrous sulphate or lactate was added. During the butter-making process care was taken to avoid contact of the materials with iron. The butters were worked the same amount, salted the same, and washed with the same amount of water and the same number of revolutions in the wash water. The samples were stored packed in glass jars with glass tops.

Unfortunately, the acidity of all the samples was too high for the butters to possess good keeping quality and marked deterioration took place in all cases. However, in every instance, on first scoring, the butters to which iron had been added scored lower than their controls. The same observation was noted in most cases on the second and third scoring, the most noticeable feature being that the butters to which iron had been added showed a much faster deterioration than the control butters.

The same workers carried out experiments to determine the effect of copper on the keeping quality (13). The same remarks as for the iron experiments are applicable.

Davies reports analytical data for the copper and iron content of various samples of Australian and New Zealand butter, together with remarks on the flavour (14). The following data is taken from his paper:—

Source and No. of Sample.	Cu Content (p.p.m.).	Fe Content (p.p.m.).	Acidity (mls. $N/_1/100$ gms.)	Remarks.
N.Z. 1 ...	9·30	...	...	Fishy, quickly followed by tallowiness (whey butter).
2 ...	1·40	...	1·77	No taint.
3 ...	2·00	...	9·10	Slightly fishy.
4 ...	1·20	...	...	No taint.
A. 1 ...	1·60	...	3·08	No taint.
2 ...	2·00	6·60	0·93	Fishy.
3 ...	0·90	5·50	1·42	Fishy.
4 ...	2·20	2·50	1·14	Fishy.
5 ...	1·70	3·80	1·32	No taint.
6 ...	3·20	1·70	3·45	Fishy.
7 ...	2·30	1·30	2·48	Fishy.
8 ...	Trace	3·00	7·90	Acid and off flavour.
9 ...	Trace	2·40	8·00	Acid and off flavour.
10 ...	1·30	1·90	...	Good samples of Australian butter.
11 ...	1·80	1·80	...	
12 ...	1·30	1·10	...	
13 ...	1·64	2·30	...	
14 ...	1·60	1·60	...	
15 ...	3·60	2·20	...	Fishy.
16 ...	2·00	0·90	...	Slightly fishy.
17 ...	2·40	2·40	...	Fishy.

In the above table it will be noted that no sample having a copper content under 1.8 p.p.m. showed defects providing that the other factors controlling deterioration were satisfactory. All samples having 2.0 p.p.m. or more of copper showed defects. It will also be noted that one sample containing 3.80 p.p.m. of iron, the other factors controlling deterioration being satisfactory, showed no defects, but a sample containing 5.50 p.p.m. of iron deteriorated.

Loftus Hills *et alia* report the following data (10):

Copper (p.p.m.).	Change of Grade (points).	pH.
0·36	1	6·9
0·36	0	6·4
0·38	0	6·3
0·38	—1	6·4
0·42	1	6·4
0·48	0	7·5
0·48	—1	6·7
0·50	—1	6·3
0·52	—1	6·2
0·52	—2	6·4
0·56	—1	7·0
0·58	—2½	5·6

The workers remark that the above table "is suggestive in that it indicates that the combined effect of acidity and copper content may be important in relation to keeping quality."

One point which has been brought forward certainly deserves attention; i.e. will the copper and iron exert little or no controlling effect on the rate of deterioration provided the acidity of the sample is correctly adjusted, or, will they have a controlling influence irrespective of the acidity? It is to be expected that because the acidity will influence the solubility of the metals, adjustment of the acidity will largely control their influence.

THE EFFECT OF TEMPERATURE UPON THE KEEPING QUALITY OF BUTTER.

When conditions in the butter are suitable for decomposition, the temperature of storage exerts a marked effect upon the rate of deterioration. The following data, taken from the work of Rogers *et alia,* shows this very markedly. (74).

AVERAGE DETERIORATION OF BUTTER AFTER STORAGE AT VARIOUS TEMPERATURES.

Kind of Butter.	Points lost after storage at—		
	0° F.	10° F.	20° F.
Raw Cream Butter—			
Creamery A	5·0	5·3	5·8
Creamery D	1·7	4·1	3·3
All Samples	3·2	4·6	4·8
Pasteurised Ripened Cream—			
Creamery B	2·2	3·0	5·1
Creamery E	1·7	3·6	4·0
Al. Samples	2·0	3·3	4·6
Pasteurised Unripened Cream—			
Creamery C	·6	1·0	1·5
Creamery D	·4	1·0	1·6
All Samples	·5	1·0	1·6

The above table indicates that, when factors which cause deterioration of butter are present, the lower the temperature of storage the slower the rate of deterioration.

When careful attention is paid to the exclusion of factors causing deterioration, the amount of deterioration may be negligible with storage temperatures as high as at least 10°F. The writer's work, previously mentioned, indicates that, with the pH adjusted between 6.7 and 6.9, over 90% of the samples may be expected to deteriorate by only 1 point or less during ten weeks cold storage at 10°F. (8).

THE GAS-CONTENT OF BUTTER.

Russel and Hastings state that "Butter contains ten per cent of air in the form of minute bubbles (44).

Rogers *et alia* examined the air enclosed in canned butter (13). As it seems highly probable that a portion of the gas obtained from the cans may not have been actually contained in the butter, the results of these workers will not be presented.

According to Pickerill and Guthrie the air-content of butter varies from 0.5 to 6.0% (in one table) and from 4.0 to 14.9% (in another table, older samples) and has an average air content of about 4% (45).

A range of air content from 1.3 to 8.4% with a mean of about 4% was noted by Rahn and Mohr (46).

Guthrie measured the volume of air contained in butter by noting the volume which could be withdrawn from it under a vacuum of 25 mm., the temperature being maintained steady at some point between 39 and 49°C. (47). He noted that in fairly well-worked butter the air content varied from 2.854 ccs. to 6.421 ccs. per 100 gms. butter, the average content being 4.651 ccs. In thoroughly worked butter the air content varied from 4.174 ccs. to 6.703 ccs., the average content being 5.374 ccs.

Arup and Gilmour made determinations of the amount of air contained in Irish butter by comparing the specific volume of the butter in the natural state with the specific volume after melting at a low temperature and allowing the contained air to escape (9). The results obtained varied from 1.6 to 5.2 ccs. air per 100 gms. of butter; the average content was about 4ccs.

From the above information it will be seen that the air content of butter averages about 4-5 ccs. per 100 gms. butter. A simple calculation will show that the greater part of the air is not contained in the serum. The moisture content of butter is about 15 to 16%, so that 100 gms. butter contains between 15 and 16 ccs. water. At 20°C. one volume of water dissolves 0.017 volume of air at standard pressure, so that 15 ccs. of water will dissolve 0.26 ccs. of air. Thus it can be seen that practically the whole of the air must be incorporated in the butter in the form of very small bubbles.

From what has been said it will be realised that butterfat is exposed to air, not only at the surface of the package, but also at the surface of innumerable air bubbles included in the mass of the butter. Since the surface exposed by a given volume of substance to a second substance in which it is enclosed rapidly increases as the degree of subdivision of the enclosed substances increases, it will be realised that the surface of butterfat exposed to the air is large; this is a condition very suitable for oxidation of the butterfat.

The Effect of Storage on the Gas-content of Butter.

Dyer has studied the changes which take place in the gas-content of butter during storage (48). The butter samples were stored in glass tubes, any free air above the surface of the butter being displaced by pure neutral paraffin oil. When it was desired to analyse the gas-content of a sample of butter, the gas was removed from the tube with a Töpler pump after the sample had been

warmed, and analysed with the usual Hempel gas apparatus. Dyer noted that: "The composition of the air confined within a package of pasteurised sweet-cream butter known to contain bacteria and made from cream having an acidity of 0.11% (calculated as lactic acid) showed little or no variation from its original composition after successive periods of storage, aggregating six months, at a temperature of 0°F. ..... A portion of this same sample of sweet-cream butter when kept at a temperature of 32°F. showed a decided change in the original composition of the enclosed air, a change which was still further increased when the butter remained for a short time at room temperature. This change in the composition of the air originally incorporated into the butter was expressed by a decrease in the percentage of oxygen and a corresponding increase in the percentage of carbon dioxide. This sample of sweet cream butter still possessed a good score after six months' storage at a temperature of 0°F., there being no indication of any undesirable flavour.

"The change in the composition of the air initially inclosed within a package of butter made from sweet cream and churned immediately after the addition of 15% of a commercial starter showed but little variation from that observed in the sample of sweet cream butter when the two samples were kept under comparable conditions, both being in storage at a temperature of 0°F., although the acidity of the cream in the first case was somewhat higher (0.25%) than that of the cream from which the sweet-cream butter was made. This sample of butter also displayed good keeping qualities during its storage period of nearly seven months at a temperature of 0°F."

The following table taken from Dyer's paper shows the results for the analysis of gas samples extracted from sweet-cream butter.

ANALYSIS OF "AIR" EXTRACTED FROM SWEET-CREAM BUTTER.

(Calculated to 0° C. and 760 mm. Acidity of Cream as Lactic Acid, 0·11% ; Salt, 1·21% ; Curd, 0·58%.)

Number of Bacteria per gm.	Time Stored at—			Oxygen.	Carbon Dioxide.
	0° F.	32° F.	Room temp.		
	days.	days.	hours.	%	%
	0	0	0	25·15	2·89
	0	2½	1	22·23	4·51
	0	15	1	15·96	7·58
9,050,000	0	41	1	9·86	11·91
	0	57	1	5·49	15·24
	81	0	1	25·51	1·49
	81	1	1	22·70	2·02
	81	13	1	20·45	2·86
	110	0	5	20·62	2·85
132,000	110	1	1	23·00	2·73
	150	0	2	24·18	1·62
	180	0	1	25·11	0·57

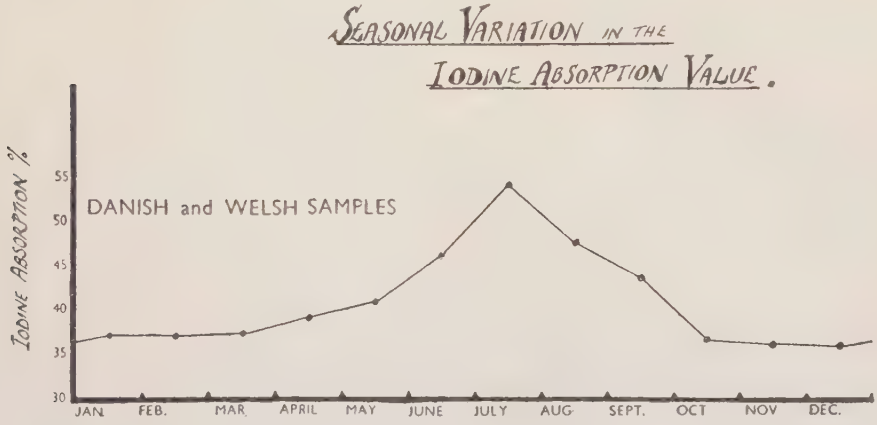
THE COMPOSITION OF BUTTERFAT.

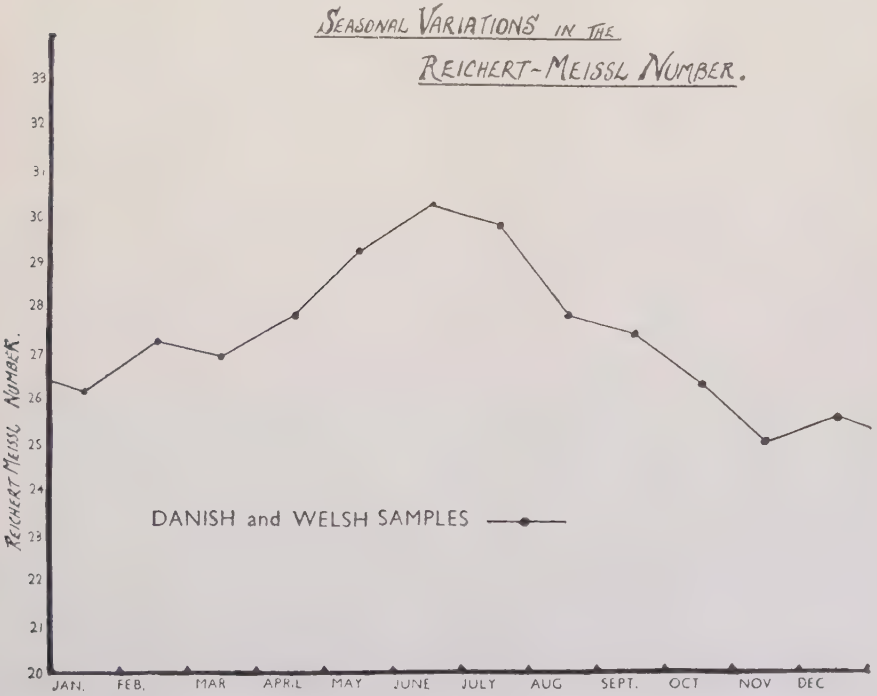
Butter contains about 80-85% butterfat. It is present in milk as an emulsion in a continuous aqueous phase, stabilised probably, as will be mentioned later, by lecithin. In the churning process the emulsion is reversed, and the water is found finely dispersed throughout the fat which is now the continuous phase. The size of the droplets is very small. Hunziker says they vary in size from less than 1 micron to about 15 microns (4). The substance forming

the stabilising membrane in milk and cream appears to be mainly destroyed during the butter-making process, probably during the heat-treatments, for upon warming butter just sufficiently to melt the fat, about 40—45°C., the fat and aqueous phases readily separate into two layers.

The determination of the composition of most fats is difficult. That the relative proportions of the constituents in butterfat vary from sample to sample is obvious from the variation of the several usually-determined analytical figures such as the Reichert-Meissl, Polenske, iodine and saponification values, etc., and from the variation of its physical properties such as melting-point and refractive index.

The following graphs, showing the variation of the iodine absorption value and the Reichert-Meissl value of Danish and Welsh butter, was presented by Davies and Griffiths (103).





The relative proportions of the glycerides have been examined by various workers. The range of probable values for the percentages of the various fatty acids is given in the following table which has been drawn up after a critical perusal of the literature on the subject. The table also shows the melting point of each fatty acid and the melting point of the corresponding triglyceride.

Fatty Acid.	Proportions.	M.P. Acid.	M.P. Glyceride.
Butyric	2·0— 5·5	—7	...
Caproic	1·0— 3·5	—8	—25
Caprylic	0·5— 1·5	16·5	8
Capric	0·3— 3·0	31·3	31
Lauric	2·5— 7·5	43·6	45
Myristic	9·5—22·5	53·8	56
Palmitic	15·0—38·5	62·6	63
Stearic	2·0—20·5	69·3	71·6
Oleic	20·0—48·0	13	...

The above table indicates that oleic acid is the one unsaturated acid generally considered to be present. If this assumption is correct the iodine value of butterfat gives a measure of the quantity of this glyceride present in the sample. If X be the percentage of this glyceride present in the sample and Y the iodine value of the sample, then

X	Y
100	86.2

86.2 being the iodine value of pure olein.

The statement that oleic acid is the only unsaturated fatty acid in butterfat, however, is not unchallenged.

Laxa and Konecny claim that an examination of the fatty acids of the liquid fat of separator slime showed that they contained 49.65% erucic acid and 21.24% oleic acid (16). Hilditch and Jones claim to have isolated as much as 4% of linolenic acid from butter (17). This subject will be mentioned again later.

The above formula for calculating the percentage of olein in butterfat only applies if the oleic acid is present as the normal compound. Reports of work with the isomers of oleic acid indicate that the farther the double bond is removed from the COOH group the nearer the iodine value is to the theoretical value. Normal oleic acid has an iodine value of 90, but 2 : 3 oleic acid has a Hübl value of 6.6, Wijs value of 20.4 and Hanus value of 1.9 (18, 19).

The iodine value of butterfat is important insofar as it gives a measure of the greater part of the low-melting point fractions. The relationship between the hardness of the butter and butterfat and the iodine number of the butterfat has been studied by Coulter and Hill (20). It was found that when a standard churning and working procedure is used, the hardness of butter is directly proportional to the hardness of the butterfat. Further, there is a highly significant correlation between the hardness of the butterfat and the iodine value of the butterfat. The data reported by Coulter and Hill shows that the relationship between the iodine value and the hardness of the butterfat is curvilinear, the hardness of the butterfat increasing very rapidly as the iodine value drops below 40.

Insofar as the iodine value is a measure of the unsaturated fraction of the glycerides, it is a measure of the portion most liable to oxidation and, possibly, a measure of the portion most active in taking up odours and flavours.

The feeding of the animals has a marked influence on the iodine value of the butterfat. This subject has been studied at the Stockholm University (21). When animals were fed on lucerne in the bud up to the full bloom stage or on young clover in bud or beginning to flower, the iodine value of the butterfat averaged about 45-47. To fix the iodine value at about 35-36 the greenstuff had to be reduced to 42-43 per cent. of the total ration.

An important point brought out by the last mentioned paper is the correlation between high iodine values of the butterfat and the development of fishy flavours in the butter.

Hill and Palmer noted that the constants of the butterfat were influenced by the feed consumed by the cows (22). The following table taken from their work shows the effect of feeding linseed oil upon the chemical constants and hardness of the butterfat.

Group.	Amount of Oil Fed.	Chemical Constants of Fat.			Relative Fat Hardness.
		Sap. Value.	I_2 Value.	R.M. Value.	
	lbs.		%		gms.
Cow 419 ... {	0·0	231·9	34·00	28·81	1138
	0·9	227·2	42·21	27·63	922
Difference	...	—4·7	+8·21	—0·18	—216
Cow 151 ... {	0·0	233·7	29·29	29·20	1885
	0·8	229·7	41·17	30·11	1047
Difference	...	—4·0	+11·88	+0·91	—838
V. ... ... {	0·0	227·7	38·17	26·33	1126
	1·25	219·1	54·28	24·34	771
Difference	...	—8·6	+16·11	—1·99	—355
VI. ... ... {	0·0	226·8	42·45	25·73	725
	1·25	218·6	50·85	22·87	685
Difference	...	—8·2	+8·40	—2·92	—40

The mean difference between the iodine and the thiocyanate values of the butterfat for the periods of basal ration feeding which preceded and followed the linseed oil test feed was 3.53. During the oil feeding period it was 4.98, showing that the linseed oil causes a definite rise in the proportion of fatty acids less saturated that oleic acid.

It seems probable that the glyceride of linolenic acid was secreted in the milk as a result of the oil-feeding. The importance of this in connection with the development of the fishy defect of butter will be discussed later.

Butterfat is characterised by a high Reichert-Meissl value. It has been found that butyric, caproic, caprylic and capric acids give Reichert-Meissl values. Thus this constant is:—

(1) A measure of the low-melting point constituents of the fat other than olein. Coulter and Hill have shown that large increases in the Reichert-Meissl value could be correlated with a low-melting point of the fat (20). Also, the graph reported in their paper showing the hardness of butterfat correlated with the iodine value indicates that some factor other than iodine value is involved.

(2) It is a measure of the constituents which upon hydrolysis will set free acids generally considered to have pronounced aromas, The aromas of the lower fatty acids have been described by various workers as follows:—

Butyric acid.—Odour resembling acetic acid, or slightly rancid. Has an unpleasant rancid odour—in the presence of ammonia like that of perspiration. A very disagreeable odour like that of rancid butter and stale perspiration. A liquid with a characteristic smell which is specially developed in dilute solution; the anhydrous acid has a sharp acid smell, the characteristic smell being hardly perceptible. An addition of 0.06 per cent. imparted to a non-rancid lard a pronounced odour which was distinctly different from that of a rancid control.

Caproic acid.—Odour of sweat. Like valeric acid has a very unpleasant and persistent odour of perspiration and rancid butter. An oily liquid with an unpleasant goat-like smell. It possessed a strong, disagreeable odour, which was in no way similar, however, to the rancid odour; in the amount of 1 per cent. it imparted to a sweet lard a sour odour totally unlike that of a rancid control.

Caprylic acid.—Odour of sweat. A faint unpleasant odour of sweat and a sharp rancid taste. Its odour was similar to, but stronger than, that of pelargonic acid, and somewhat suggestive of coconut: when added to sweet lard in the amount of 1 per cent. it imparted to the lard an odour weaker than that of a rancid control and of a different type. (In connection with the last opinion, the same worker said of pelargonic acid: It was found to have a mild odour, and in small quantities was without appreciable effect on the odour of a non-rancid lard to which it had been added).

Capric acid.—Odour of sweat, less pronounced than in the above. A faint goat-like odour.

To the writer it seems very doubtful whether any of the above acids in a perfectly pure condition have any pronounced disagreeable odours and flavours. If a Reichert-Meissl test is made upon butterfat from perfectly fresh material there is no pronounced odour or flavour other than a sharp acid odour in the distillate, and yet all the above acids should be present in the distillate.

THE OXIDATION OF BUTTERFAT.

In the first place it must be noted that much of the literature published in connection with the deterioration of butterfat, particularly the earlier work, is most difficult to review because of the confusion of the terms rancid, oxidised, etc.

It is very difficult to prepare a sample of pure butterfat, meaning by that phrase a pure sample of the glycerides of the fatty acids. As ordinarily obtained, butterfat contains dissolved in it vitamine-A in small quantities and varying quantities of the phospholipids. It seems doubtful whether any experiments have yet been made on butterfat which has been freed from both these substances. The bleaching of the colour of the fat phase is not due to oxidation of the fat but to oxidation of the carotinoid materials dissolved in the fat. It follows that the bleaching does not necessarily indicate any change in the nature of the glycerides. It may be that actually oxidation of these materials in the fat takes place before the fat itself is attacked. It is very likely that in butter, and more particularly in milk, there may be present substances which will absorb the oxygen preferentially to the fat, and that the fat itself will not start to oxidise until these other materials have been first oxidised, or at least mainly oxidised. In the case of milk, a number of observers consider that the oxidised flavour becomes apparent at about the time the ascorbic acid is practically all oxidised (23).

The experiments which have been made to study the oxidation of more or less pure butterfat, have usually been made at elevated temperatures. In such conditions it is possible that inter-molecular changes take place between the dissolved substances and the fat, and, of course, the same changes or similar changes may take place at more normal temperatures, but at a slower rate. In any case, the course of oxidation of butterfat at elevated temperatures may be quite different from the course at lower temperatures, and the products formed in a more or less pure sample of butterfat may be quite different from the products formed in the presence of other milk constituents.

The latter observation appears to be borne out in practice by the observations of Hunziker and Hosman (24). These workers conclude that the tallowy flavour usually associated with oxidation of the butterfat is produced by compounds of glycollic acid with fatty acids. In the case of pure butterfat they suggest the glycollic acid is produced by oxidation of free glycerol derived from the fat, but in the case of butter the glycollic acid is probably formed by oxidation of lactose. They found that a distinctly tallowy defect could be produced by the addition to butterfat of 0.25% of the glycollic acid ester of oleic acid.

Briggs made experiments with the fatty phase of butter separated from the aqueous phase (25). He observed that, when the material was held at 100°C. and well stirred in an atmosphere of oxygen, there was a so-called "induction period" prior to the active absorption of oxygen. Other workers have observed the same phenomenon (26,27). Briggs showed that during the induction period changes were actually taking place in the fat, the peroxide test giving positive findings early in the process. The following is a set of peroxide values reported by Briggs (28):—

Time (hours).	Peroxide Content (% x 10^4).	Time (hours).	Peroxide Content (% x 10^4).
0	...	10	18·0
1	5·0	11	19·2
2	3·8	12	22·3
3	7·1	13	21·1
4	8·8	14	23·7
5	10·2	15	32·8
6	10·1	16	30·6
7	11·0	17	33·1
8	14·5	18	47·8
9	15·0	19	349·2

"Induction period," 18¼ hours.

It will be noted that after the "induction period" the rate of increase in the peroxide value was very rapid.

A number of explanations are possible for the phenomena noted above. In the first place, the method of measurement of oxygen volumes may not have been sufficiently sensitive to note the small oxygen absorption during the induction period. On the other hand there may have been no absorption of oxygen from the atmosphere, with oxidation of the fat being due to an inter-molecular change with other materials dissolved in the fat. The change taking place during the induction period may be oxidation of constituents other than the fat and, when the first small quantity of fat is oxidised this may act as a catalyst to the remainder. This appears to be borne out by the fact that small quantities of old butterfat materially shorten the induction period of fresh butterfat.

Odours and flavours due to Oxidation:

Oxidation of oleic acid itself gives rise to substances having very strong odours. It is likely that the first stage in the oxidation of this acid consists in the addition of oxygen at the unsaturated bond as follows:—

$$CH_3\ (CH_2)_7\ CH = CH\ (CH_2)_7\ COOH$$

$$\downarrow$$

$$CH_3\ (CH_2)_7\ CH - CH\ (CH_2)_7\ COOH$$

$$O \text{ —— } O$$

Further change can easily give rise to the following compounds

$CH_3\ (CH_2)_7\ CHO$,	$CHO\ (CH_2)_7\ COOH$
nonyl aldehyde	azelaic half-aldehyde

and

$CH_3\ (CH_2)_7\ COOH$,	$COOH\ (CH_2)_7\ COOH$
nonylic or pelargonic acid	azelaic acid.

This sequence of changes for the oxidation of oleic acid, i.e., absorption of oxygen with the formation of peroxides followed by breakdown of the peroxide to give aldehydes and acids, is strengthened by the findings of Briggs that, whereas positive peroxide tests were obtainable as soon as oxidation of the fat commenced, tests depending upon aldehydes were only obtainable after the lapse of some time (28).

Briggs notes that it has been shown that among the chief decomposition products of oleic acid are to be found oxido-oleic acid, dihydroxy-stearic acid, azelaic and nonylic acid (28). The aldehydes have strong odours in small concentrations. In the case of nonyl or pelargonic aldehyde small quantities impart to substances a characteristic fine odour and it is used at a concentration of 1 : 1000 in artificial rose attar (49). Powick says of the aldehyde: "Its odour was distinctly suggestive of the odour of rancidity, but of a rancid odour modified by a somewhat pleasing and fragrant quality. When added in small quantity to a sweet lard it imparted to the lard an odour very suggestive of the rancid odour, but lacking in some indefinable quality" (42). Powick's sample of the aldehyde was probably impure. Harries and Turk described azelaic half-aldehyde as a white solid that is ordinarily possessed of a weak odour, but which gives off a strong rose-like odour when warmed (50).

Powick examined a large number of known fat decomposition products (42). Whilst some of the compounds examined may not have been perfectly pure—some showed a slight range of boiling point—it can be assumed that they were largely pure, and, if the odour associated with rancidity was not characteristic of them, they could be assumed not responsible for this defect in butter. Powick says: "As a result of the direct examination of the following compounds, it appears that none of them contributes appreciably, if at all, toward the rancid odour of fats:

Hydroxystearic acid	Heptylic acid	Butyric aldehyde
Dihydroxystearic acid	Caprylic acid	Acrolein
Diketostearic acid	Nonylic acid	Crotonic aldehyde
Formic acid	Azelaic acid	Methylglyoxal
Acetic acid	Acrylic acid	Dihydroxyacetone
Butyric acid	Formaldehyde	
Caproic acid	Acetaldehyde	

"It also appears, on theoretical grounds, that neither ketoxystearic acid nor azelaic half-aldehyde contributes to the odour of rancid fats. Direct examination of nonylic aldehyde, on the other hand, suggests that this compound may be partly responsible for the rancid odour." On the other hand, "The odour of heptylic aldehyde in itself and in presence of fresh fats is sufficiently suggestive of the rancid odour to establish the reasonableness of Scala's contention that it is the component of rancid fats that is primarily responsible for their rancid odour."

It is difficult to understand how normal oleic acid can give rise to heptylic aldehyde. The production of the aldehyde would involve either breakdown at a saturated linkage in the molecule or shift in the point of unsaturation during the oxidation process. It seems more reasonable to assume that breakdown of normal oleic acid gives rise to nonylic aldehyde and azelaic half-aldehyde and that the hepylic aldehyde is produced from an isomeric form of oleic acid.

The old contention that rancidity is due mainly to free butyric acid is certainly not correct. The flavour and odour of pure butyric acid, either concentrated or in dilute solution is not so obnoxious as past workers would have us believe. Powick's observation is noted above. Butyric acid is used commercially in artificial butter flavours, and the finer the quality of the material the better the odour. The following formula for "Butterscotch Basic Ether" is taken from Walter's "Manuel for the Essence Industry."

Ethyl oenanthate	½lb.
Ethyl pelargonate	1lb.
Butyl butyrate	1¼lb.
Amyl acetate	1¼lb.
Ethyl butyrate	1½lb.
Butyric acid	2½lb.

Thurston *et alia* have shown that the typical "oxidised flavour" of milk products is probably associated with compounds formed by the oxidation of lecithin (51). These workers washed cream with water 14 times, separating the cream after washing. The oiling-off of the cream towards the end of the process indicated the removal of the stabilising membrane from the fat globules. No organic phosphorus could be detected in the washed butterfat. The washed butterfat was dispersed in fresh skim milk of good flavour by "homogenising" at a pressure adjusted to give fat globules of the size found in the original milk. After 0.01 per cent. copper had been added to it and air bubbled through it for 24 hours, it had no "oxidised flavour." Fresh milk, similarly treated, had a strong "oxidised flavour." These workers also noted that the strength of the "oxidised flavour" developed in a milk product was influenced by the lecithin content, the greater the lecithin content the stronger the flavour developed.

The Kreis Test.

Powick found that neither any of the fat decomposition products mentioned above nor oleic acid ozonide is responsible for the development of the colour in the Kreis test (42). He considers that, on theoretical grounds, oleic acid peroxide, azelaic half aldehyde and ketoxy-stearic acid may also be eliminated as being responsible for the test, whilst glyceric aldehyde is eliminated on the basis of statements in the literature.

He found that the colour obtained in the Kreis test with rancid fats is spectroscopically identical with that obtained in the Kreis test with mixtures of acrolein and hydrogen peroxide, and that the substance responsible for the colour

production is epihydrin aldehyde CH_2—CH.CHO. The constituent of rancid fats
$\quad\quad\quad

A measure of the rate of oxidation of butterfat seems, therefore, to be a direct measure of the rate of deterioration even though the direct end product of this reaction—tallowiness—may not be noted in the scoring" (53).

From the data included in this paper, the writer concludes that there are two main types of reactions responsible for the deterioration of butter: oxidative and hydrolytic. These reactions, at least in the majority of instances, are almost certainly not interdependent; almost as certainly they are proceeding simultaneously. As a consequence the writer regards the ideas of Holm *et alia* as fundamentally unsound.

The Influence of Various Factors on the Rate of Oxidation.

Holm *et alia* noted that the rates of deterioration of sweet cream butters and butters made from creams of less than 0.20 per cent. acidity, developed by pure cultures added to sweet creams, were practically identical.

Butters made from cream of 0.3 per cent. or greater acidity were found to be inferior in keeping quality to those made from sweet cream.

The same workers noted that an acid condition in the material is apparently the requisite for the development of fishy flavours. The amount of peroxide developed in sweet cream butters was often equal to or greater at the end of the storage period, than the amounts in the acid-cream butters when the latter developed a fishy flavour, yet none of the butters made from cream of an acidity of 0.2 per cent. or less developed a fishy flavour.

Wiley carried out experiments using the fat-aldehyde value as a measure of the degree of oxidation of the butterfat (52). His results showed that acidity, the presence of materials derived from the starter organisms, salt, and low temperatures of pasteurisation all favour oxidation. The starter organisms elaborate some material which favours oxidation, and is destroyed by pasteurisation. The pro-oxidant is neither diacetyl nor acetoin. The most important factors are metallic contaminants and the extent of exposure to light. For a review of the literature on the effect of light on oxidation of butterfat, Stebnitz and Sommer's paper, "The Oxidation of Butterfat," may be consulted (29). For a review of the literature on the effect of metals on the oxidation of butterfat, the paper "Factors Influencing the Initial Induction Period in the Oxidation of Milk Fat," by Henderson and Roadhouse may be consulted (30).

Briggs' experiments with the fatty material may be mentioned (25). He reported the following data showing the reduction in the duration of the "induction period," the material being stirred in an atmosphere of oxygen and maintained at a temperature of 100°C.

INFLUENCE OF METALS.

Experiment.	Con. of Catalyst.	Ind. period (hours).
Control (*a*)	...	$21\frac{1}{2}$
Control (*b*)	...	$19\frac{3}{4}$
Sodium vanadate	$4 : 10^6$	$2\frac{1}{2}$
Copper lactate	$4 : 10^6$	3
Iron lactate	$4 : 10^6$	15
Nickel sulphate (*a*)	$4 : 10^6$	18
Nickel sulphate (*b*)	$4 : 10^6$	19
Zinc lactate	$4 : 10^6$	25
Control	...	$14\frac{1}{2}$
Copper lactate	$1 : 10^6$	$3\frac{3}{4}$
Copper lactate	$1 : 10^7$	8
Copper lactate	$1 : 10^7$	$8\frac{1}{4}$

INFLUENCE OF METALS—*continued.*

Experiment.	Con. of Catalyst.	Ind. period (hours).
Copper lactate	·5 : 10^7	10
Copper lactate	·25 : 10^7	11
Control	...	25
Copper lactate	1 : 10^6	$3\frac{1}{2}$
Sodium pyrophosphate	2 : 10^6	
Copper lactate	1 : 10^6	$1\frac{3}{4}$
Sodium pyrophosphate	2 : 10^6	
3 controls	...	Mean $17\frac{1}{4}$
Iron lactate	4 : 10^6	$13\frac{1}{2}$
Iron lactate	7 : 10^6	$12\frac{1}{2}$

The table shows that copper lactate at a concentration of 1:40x10^6 had a very appreciable effect in reducing the duration of the "induction period." The attempts to diminish the action of the copper by formation of the pyrophosphate were unavailing. The effect of nickel salts was slight and zinc lactate appeared to have a slight retarding effect and increased the duration of the "induction period."

Consistent with the findings that traces of copper accelerate the production of oxidation defects, is the fact that copper in traces raises the redox potential of milk products (31). Further, factors which will lower the redox potential such as large numbers of bacteria in milk (32), or the addition of reducing substances to cream (33), will prevent the development of defects due to oxidation.

The following data shows the effect of adding copper to milk and also the effect of bacteria (34).

OXIDATION—REDUCTION POTENTIAL OF MIXED COWS' MILK.

Time elapsing after setting sample. (hours)	Samples stored at 70° F. for 5 hrs., 40° F. for 14 hrs.		Samples stored at 40° F. for 19 hrs.	
	Control.	Cu added 2·6 p.p.m.	Control.	Cu added 2·6 p.p.m.
	Eh	Eh	Eh	Eh
$\frac{1}{2}$	·29402	·32291	·30730	·30987
$1\frac{1}{2}$	·28795	·33864	·31315	·30721
$2\frac{1}{2}$	·27878	·37288	·31262	·30342
4	·25630	·34756	·31226	·30150
5	·25980	·37105	·30420	·29877
6	·26390	·37016	·30337	·39891
19	·15837	·28208	·30242	·43803
Degree of tallowiness after 24 hrs.	...	...	...	+ + + +

The effect of bacteria in tending to reduce the potential is particularly noticeable in the case of the first set of samples where conditions are favourable for bacterial growth.

Webb & Hileman found that the addition of traces of copper to milk and cream raised the redox potential to about 0.45 volt (31).

Chilson showed that the addition of ascorbic acid to milk prevents the development of oxidised flavour (35).

Brown *et alia* found that feeding greenstuffs, tomato juice, lemon juice or ascorbic acid to the animals, reduced the tendency of milk to develop oxidised flavour (36).

In experiments to test the effect of light Briggs found that, whereas the control experiment gave an "induction period" of 17¼ hours, the experiment in which the fat was exposed to ultra violet light from a mercury arc lamp gave an "induction period" of only 5½ hours (25).

Briggs also reports the following data showing that oxidised fat and lactic acid decrease the duration of the "induction period" whereas curd increases it.

Experiment.	Conc. of Material Added.	Induction Period. (hours)
4 Controls	...	Mean 15½
Oxidised fat	1%	8½
3 Controls	...	Mean 15¾
Lactic acid	0·1%	11¾
3 Controls	...	Mean 17¼
Lactic acid	0·1%	12
Control	...	17¾
Curd added	...	30¾
2 Controls	...	Mean 20½
Curd added	...	32½
Control	...	30
Curd added	...	27¾

As noted by Briggs the curd is partially decomposed at the high temperature of the experiment; its action probably will not be the same at low temperatures.

Kieferle & Senss report that butter wrapping materials may be classed in order of efficiency as protective materials as follows: parchment, cellophane, ultrament, tin or aluminium foil (37). (Ultrament is a proprietary vegetable parchment impregnated with a yellow dye.)

Barnicoat tested various wrapping materials and his report indicates the great superiority of covering materials composed of metal foils waxed to parchment (38). Of transparent cellulose wrapping materials, red coloured material proved best.

Emery and Henley found, when working with lard, that exposure of the fat to air did not in itself produce a rancid condition (39). The presence of a metal catalyst or exposure to light was necessary to produce rancidity.

Coe *et alia* noted a similar light effect (40). When an oil was not exposed to light high peroxide values could be developed without the oil becoming rancid. Such oils which have developed high peroxide values in the absence of light and which have no rancid defect, become rancid upon exposure to light. When cottonseed oil was protected from light the oil did not become rancid even though the peroxide value had reached 200 m. moles per kilo. When not protected from light, rancidity developed when the peroxide value reached 60 m. moles per kilo. Oils which had developed peroxide values of 60 m. moles per kilo or greater in darkness, turned rancid upon exposure to light.

Baumann and Steenbock found that maxima of light absorption occurred at wavelengths of 460 and 485 mμ (41).

THE "CURD" CONTENT OF BUTTER.

The curd content of butter is usually slightly over 1 per cent. The proteins of milk are mainly casein, about 3 per cent., and lactalbumin, about 0.4 to 0.5 per cent. Mitchell and Hamilton quote the following data for the amino acid content of these substances (54).

Although the exact composition of neither material is known exactly, the approximate proportions of the various amino acids are known.

Amino-acid.	Percentage Present in—	
	Casein.	Lactalbumin.
Glycine	0·4	0·4
Alanine	1·8	2·4
Valine	7·9	3·3
Leucine-iso-leucine	9·7	14·0
Aspartic acid	4·1	9·3
Glutamic acid	21·8	12·9
Hydroxy glutamic acid	10·5	10·0
Serine	0·5	1·8
Proline	8·0	3·8
Hydroxy proline	0·2	...
Phenylalanine	3·9	1·2
Tyrosine	6·5	1·9
Cystine	0·3	4·0
Arginine	5·2	3·0
Histidine	2·6	1·5
Lysine	7·6	8·4
Tryptophane	2·2	2·7
Ammonia	1·6	1·3
Total	94·8	81·9

The Decomposition of Proteins in Butter.

It is characteristic of the heterotrophic group of bacteria that they elaborate exo-cellular enzymes which break down proteins into fragments sufficiently small to diffuse into the cell and become available for cellular metabolism. Acids also cause hydrolysis of proteins. Thus, it is found that, as cream and butter age, the percentage of the nitrogen present as amino-nitrogen increases.

One constantly reads of the groups of proteolytic and non-proteolytic organisms and of tests for distinguishing the two types, but it seems reasonable to assume that there are no such hard and fast groups, and that there are all types of organisms ranging from such as only break down small quantities of protein sufficient for their own requirements to those which elaborate large quantities of proteolytic enzymes thus causing amino-acid production far in excess of their actual requirements.

Now the breakdown of the butter proteins to amino-acids produces at least one substance known to have a very strong flavour. This substance is glutamic acid. Glutamic acid is produced commercially by the hydrolysis of gluten with acid and is used as a meat flavour in China and Japan.

Depending upon conditions and the species involved, bacteria may cause further break-down of the protein and produce undesirable substances such as indol. The necessary condition for this activity appears to be lack of available carbohydrate. Lactose, the carbohydrate present in butter, is only present in small quantity, a fraction of a per cent, and is utilised by a comparatively small percentage of species. Thus, it follows that conditions are suitable for extensive protein degradation, particularly by such organisms as are unable to utilise lactose for their energy requirements.

There appears to be confusion among writers regarding the expression "protein sparing effect of carbohydrate." The expression probably originated from the observation that, in the presence of utilisable carbohydrate, such products as indol are not formed. Some workers have demonstrated that in the presence of the carbohydrate there is generally a greater quantity of protein decomposed. There is no doubt about the observations. It appears that the phenomena mentioned are bound up with the type of material used by the organisms for the production of energy. For this purpose utilisable carbohydrate is preferred, in which case a vigorous growth of the organisms takes place, but the extent of the protein degradation is only sufficient to produce substances permeable to the cell membranes, within which it is utilised for building up cell protein. In the absence of utilisable carbohydrate less vigorous growth takes place, but the organisms must draw upon protein matter for energy supply as well as for their anabolic processes. To produce the energy—hydrolyses produced bacteriologically involve small energy changes—break-down of protein in other ways is required with consequent production of noxious substances.

Mitchell and Hamilton cite the following examples of the effect of utilisable carbohydrate upon bacterial metabolism (54).

Organism.	Significant product in protein medium.	Significant change in the carbohydrate protein medium.
Diphtheria bacillus	Sol. diphtheria toxin ...	Lactic acid. No toxin.
Shiga's bacillus	Sol. Shiga toxin	Lactic acid. No toxin.
Bacillus coli	Indol	Lactic acid. No indol.
Bacillus proteus	Sol. proteolytic enzyme ...	Lactic acid. No enzyme.

It should be noted that in the second instance cited in each case, the medium still contains protein. The only difference from the first medium is the addition of utilisable carbohydrate.

In this connection, it is well known that the addition of sugar to cream helps it to retain a sweet clean flavour. This may be due to:—(1) increasing the available carbohydrates and thus altering the bacterial metabolic products; and (2) raising the osmotic pressure of the serum to a value unfavourable for bacterial growth.

Organisms which do not attack carbohydrates probably differ from the above described course in their metabolic activities. The great majority of such organisms do not produce indol, and it follows, therefore, that they do not derive energy by breaking down tryptophane to give indol. However, they may attack one or more of the other amino-acids derived from protein for the purpose of energy production. Organisms behaving in this manner include, for instance, the species contained in the genera Alcaligenes, Brucella and Kurthia (Zopfius).

So far as is known, there are very few organisms which do not attack carbohydrates and which do produce indol. Before concluding that such organisms do not prefer carbohydrate—possibly rare compounds to which their normal habitat has adapted them—as a source of energy, it would be necessary to examine their action on a very large number of carbohydrates.

Let us briefly consider the factors causing protein cleavage. These include enzymes derived from the cream, enzymes derived from the microbial flora, and purely chemical factors including catalysts. All these factors may operate in cream.

However, with modern methods of butter-making, which include the high temperature treatment of cream in pasteurisation and deodorisation in "Vacreators," the effect of the enzymes originally present in the cream can be largely, if not entirely, neglected.

Ferris noted that, as cream decreased in grade, there was an increase in the percentage of nitrogen present as amino-acids and ammonia (55). The following table shows results reported by him.

AMINO-NITROGEN AND AMMONIA AS PER CENT. OF TOTAL NITROGEN, SHOWING RANGE FOR FIRST AND SECOND GRADE CREAMS.

Plant No.	First Grade.		Second Grade.	
	Minimum.	Maximum.	Minimum.	Maximum.
1	1·1	2·0	...	...
2	1·5	2·1	...	...
3	5·5	5·8	...	...
4	5·5	6·9	7·7	9·1
5	6·4	7·7	8·7	9·0
6	7·0	7·1	8·4	9·1
7	6·7	8·0	8·5	8·9
8	6·8	8·0 (8·7)	8·6	...
9	6·5	7·9	8·4	10·5
10	7·3	8·3 (9·4)	8·6	10·5
11	7·0	8·7	11·7	12·2
12	7·5	9·2	11·9	12·2
13	9·0	10·0	11·5	13·3

It will be seen that, in the case of every plant, cream graded second contained a higher percentage of nitrogen present as amino-nitrogen and ammonia. Taking into account the fact that the graders at the various factories will not in general have the same standards for the different grades of cream, it is interesting to note how close agreement was obtained in selecting as first grade, creams which upon analysis were found to contain not more than about 8% of the nitrogen as amino-acids plus ammonia.

Jacobsen studied the relationship between the amino-nitrogen content of cream and the grade (56). His results, whilst not so definite as those obtained by Ferris, are similar. The following table shows data taken from Jacobsen's paper.

AMINO-NITROGEN CONTENT OF CREAM OF THREE GRADES.

Grade.	No. of Churnings.	Description.	Av. amino-N.
1	5	Sweet, clean, below 0·20% acidity	4·82
2	10	Slightly off-flavoured, below 0·60% acidity ...	5·17
3	12	Markedly off-flavoured, above 0·60% acidity or both	6·45

Jacobsen's figures for the range of amino-acid contents of cream samples in each grade is, as with the results obtained by Ferris, fairly wide. This is only to be expected, for the quality of cream may be low because of factors other than decomposition. Jacobsen said: "In general, it may be noted that cream of low acidity showed a low percentage of amino-nitrogen and produced

a butter of high flavour score. Conversely, the high acid cream showed higher amino-nitrogen content and lower butter score. Exceptions, however, will be noted . . . where feed flavours were responsible for the low butter flavour scores received." The position may be stated as follows: cream which is low grade because of decomposition has a higher amino-nitrogen content than good cream but, cream may be low grade for reasons other than decomposition: for instance, it may have pronounced feed taints.

The value of any method for grading cream depends on its usefulness in classifying the cream samples according to their potential butter-making quality. It is desirable, therefore, to inquire how closely grading according to soluble-nitrogen content satisfies this criterion. The following table, taken from Jacobsen's paper shows the flavour scores of butter samples made from cream graded on its amino-nitrogen content.

Per cent. amino-N.	No. of Churnings.	Butter flavour Scores.	
		Range.	Average.
<5%	7	33—38	35·9
5–6	12	34—37	35·3
>6	8	31—34	32·2

From the table it will be noted that: "Cream containing more than 6% of the total nitrogen as amino-nitrogen made butter of significantly lower flavour score. Cream of lower amino-nitrogen content showed considerable variation."

Rahn *et alia* noted that, the poorer the quality of butter at the end of the storage period, the greater the increase in the amino-nitrogen which had taken place (57).

Hunziker & Spitzer found that the increase of soluble nitrogen compounds in butter held in cold storage was closely related to the quality of the butter (as shown by the flavour score) when it went into store and also at the end of the storage period (58).

The following table shows the increase in one of the soluble nitrogen fractions accompanying a given change of score in the exhibition samples at the U.S.A. Dairy Show in 1926. The figures were obtained by Spitzer and Parfitt (59).

Change in Score.	No. of Samples.	Increase in N. not precip. by Phosphotungstic Acid.
		%
Increased	6	0·62
Loss of 0·5 point	6	0·71
Loss of 1·0 point	5	0·82
Loss of 1·5 point or more ...	6	0·97

THE LECITHIN CONTENT OF BUTTER.

The phospholipid content of milk and of various milk products has been determined recently by Holm *et alia* (60). Results reported are as follows:—

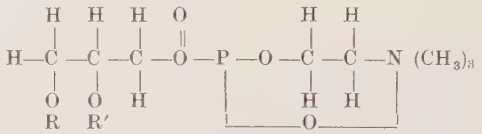
Whole milk	0.0337%
Skim milk	0.0169%
Cream (41% fat)	0.1816%
Butter	0.1819%
Buttermilk	0.1872%

During the butter-making process the phospholipid content was found to be distributed as follows:—

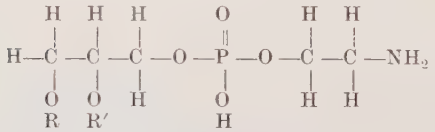
Whole milk (fat 3.88%)	100.0%
Skim milk	45.28%
Cream	52.30%
Buttermilk	28.34%
Butter	24.73%

The above figures are calculated from the organic phosphorus content of the various materials assuming a phosphorus content of 4% for the phospholipid fraction. The assumption of the phosphorus content given is based upon the work of Kurtz *et alia* (61). The assumption that the relative proportions of the constituents of the phospholipid fraction remains constant in the milk and various milk products may not be correct, but likely variations will not alter the above figures greatly.

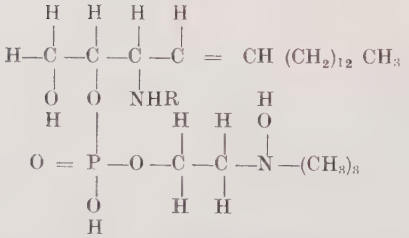
Kurtz *et alia* found the ratio of the constituents in the phospholipid fraction of milk to be lecithin: cephalin: sphingomyelin as 8.4 : 4.5 : 1. The constituents have the following formulae:—



LECITHIN.



CEPHALIN.



SPHINGOMYELIN.

The symbols R. and R′ in the formulae represent fatty acid groups. Analysis of the lecithin-cephalin fraction indicated the fatty acid content to be: myristic acid 5.2%, stearic acid 16.1%, arachidic acid 1.8%, oleic acid 70.6%, dicostetrenoic acid (?) 6.3%. The acids of the cephalin-sphingomyelin fraction are comprised almost entirely of lignoceric acid.

Although vague statements are made regarding the effect of proteins as stabilisers of the milk emulsion, it would appear that the stabilisation is largely, if not entirely due to the lecithin. The emulsion is not destroyed by pasteurisation, which process would be expected to break-down the emulsion if it were stabilised by proteins. The emulsifying properties of lecithin are well known;

commercially, preparations of lecithin derived from soy beans are used for stabilising emulsions. The difficulty of separating lecithin from butterfat has long been noted (13). Thurston *et alia* describe experiments of cream washing to obtain pure butterfat (51): "Lot 2 cream was converted into washed butterfat in order to remove from the butterfat the substances absorbed on the fat globules. The cream was diluted to a volume of about 3 gallons with water at approximately 100°F., separated by means of a De Lavel No. 17 separator, rediluted, and separated until the cream had been washed 14 times or more. Near the end of this procedure a noticeable oiling-off of the butterfat occurred, which indicated that the fat globules no longer were stabilised. Further washing caused a complete oiling-off of the butterfat."

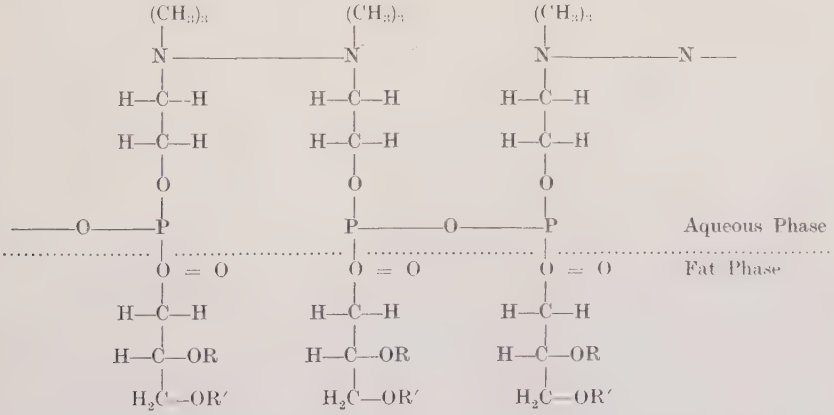
The writer has found that commercial lecithin is a satisfactory material to employ for the re-emulsification of low grade butter prior to renovation. For a small churning the process is carried out as follows:—

The contents of ten 56 lb. cases of butter are broken up and warmed with 56 gallons of water. A small quantity of melted fat is skimmed off the material in the vat and used to dissolve the emulsifying material, 2½ lbs. of commercial material containing 60-65% lecithin.

The lecithin solution is then spread as evenly as possible over the surface of the fat and gently mixed into the fat layer. Beaters are started and when an even mixture is formed in the vat the material is passed through the "vacreator."

The butter emulsion leaves the latter apparatus as a stable emulsion which may be churned in the usual manner as when churning fresh cream.

The writer conceives a monomolecular (?) film at the surface of the fat globules, arranged somewhat along the following lines, as probably forming the important stabilising membrane.



However, a protein is also closely adsorbed on the fat globules (62).

THE DECOMPOSITION OF LECITHIN AND ITS EFFECT UPON THE QUALITY OF BUTTER.

A perusal of the literature indicates that certain butter defects probably have a common origin. These defects are: a sensation of oiliness to the palate, metallic flavours and fishy flavours. This point has certainly been noted since

1909 when Sommerfeld reported that the oily taste of butter is often accompanied by a fishy taste (63). Rogers pointed out in 1914 that fishiness may be preceded by an oily or a metallic flavour (64, 65). Washburn & Dahlberg found there was a tendency for the development of the defects called metallic flavour, an oily sensation to the palate, and a fishy flavour in sequence (5). Some of the results reported by the latter workers in this respect will be noted later.

It is well known that the fishy flavour of herring and mackerel brines is largely contributed by the substance trimethylamine, $N(CH_3)_3$. This substance might be produced from lecithin by decomposition of the chlorine group, $(CH_3)_3\ N(OH)\ CH_2\ CH_2\ OH$. If trimethylamine is the cause of the taint in fishy-flavoured butter, the substance should cause the defect when worked into fresh clean-flavoured butter. The experiment was carried out by Supplee (6). He added trimethylamine and a number of its compounds (lactate, butyrate, oleate, stearate, the mixture of compounds formed with the insoluble fatty acids from butter, and the mixture of compounds formed with the soluble fatty acids from butter) to butter to give a concentration not exceeding 85 p.p.m. of butter. The review of his experiments says: "While there are several conflicting opinions as to the presence of the fishy flavour in any particular sample, it is nevertheless evident that the greatest number of positive comments is found in the samples containing trimethylamine in one form or another. It will also be noticed that usually the greatest uniformity of such comments is found in the samples containing trimethylamine in unstable form. This is particularly true as to the samples to which trimethylamine was added alone, in combination with butyric acid, or in combination with the mixed soluble fatty acids of butter. These results are in harmony with the volatility, the taste and the odour of the compounds in pure state. The lack, in a few instances, of a majority opinion with regard to the samples containing trimethylamine oleate, trimethylamine stearate, and trimethylamine with the mixed insoluble acids, might be explained on the basis that, since these substances are so extremely unstable, the trimethylamine had nearly all volatilized before the time of scoring." A table from Supplee's paper has been reproduced in the section dealing with the effect of salt upon the flavour of butter.

Sommer and Smit also tried the effect of working trimethylamine into butter (1). These workers incorporated trimethylamine lactate into butter to give a concentration of 100 p.p.m. and then submitted the material to judges and laymen for criticism: it was described as fishy by all.

If trimethylamine is the cause of the fishy taint in butter it should be possible to separate it from fishy-tainted samples but not from fresh, clean flavoured samples. This has been achieved by Sommer and Smit (1). The following data is reported by them:—

Sample No.	Description of Sample.	Trimethylamine.
1	Fresh butter	None
2	Fresh butter	None
3	Fishy butter. Commercial Sample No. 1	32·65 p.p.m. 32·45 „
4	Fishy butter. Commercial Sample No. 2	22·37 „ 22·37 „
5	Fishy butter. Sample of experimental butter furnished by Hunziker	35·97 „ 35·52 „
6	Fishy butter. Experimental butter containing 0·4% acid and 0·1% iron lactate	23·72 „ 23·80 „
7	Fishy butter. Experimental butter containing 0·6% acid and 0·1% iron lactate	25·2 „ 25·1 „

The assumption that trimethylamine is the product involved considered together with the assumption that lecithin is the substance forming the stabilising membrane, will explain why the various defects mentioned above may occur about the same time or alone. Decomposition of the lecithin would gradually break down the emulsion giving rise firstly to a cold metallic sensation and later to an oily sensation. If the choline fraction were so far disintegrated as to free the trimethylamine, fishy flavours would develop, but, if it were not decomposed to give trimethylamine, such a flavour would not be produced.

The assumption that trimethylamine derived from lecithin is the cause, in most instances, of fishy flavour of butter, however, does not preclude the possibility of such a flavour being due to other causes in some instances.

It is well known that butter stored near materials having strong aromas, such as fruit, will readily absorb such aromas. Oliver attributed fishy defects in butter to storage near fish (66).

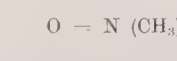
The effects of some feeds upon the flavour of milk is well known. Lewkowitsch (67) and other writers state that the trouble may be caused by feeding fish meal.

Kirchner stated that a fishy defect may be caused by feeding oil cakes (68). Linseed oil-cake feeding is fairly common practice, and the fat of this material contains appreciable quantities of linolenic acid. The work of Hill and Palmer, previously mentioned, indicates that highly unsaturated glycerides from linseed oil are secreted in the milk of cows fed with the oil (22). Hydrolysis of the fat of butter made from such milk would probably free linolenic acid along with other glycerides. Linolenic acid has a fishy odour (15, 69).

Work at the Stockholm University indicated a correlation between high iodine values for the butterfat and the development of fishy flavours in the butter (21). High iodine values were found for the butterfat of cows fed on large quantities of young leguminous crops. Here again, a similar explanation to the last suggests itself: or possibly the explanation may be as in the next instance.

Cows fed large quantities of sugar beet waste are prone to yield milk with a fishy taint. Such waste contains betaine in appreciable quantities and Davies has found that the main metabolite of this substance in the cow is trimethylamine oxide (71).

Betaine



Trimethylamine oxide

Davies found that diffusion of the latter compound readily takes place between the milk in the udder and the blood stream (72). It appears, therefore, as though the fishy flavoured milk produced by cows fed on quantities of beet waste is almost certainly due to the secretion of trimethylamine oxide in the milk.

Sommer and Smit, from their review of the literature, concluded that there was a very general agreement regarding the factors that favour the development of fishiness in butter (1). These factors are: a high acidity in the cream; a high salt content of the butter; overworking in the manufacture of the butter; and metallic contamination of the butter. To verify these conclusions they conducted the following experiment:—

Sweet cream, 400 lbs., was divided into ten lots of 40 lbs. each as follows:—

Lot 1.—Raw, unripened.
Lot 2.—Raw, naturally ripened, acidity 0.4%.

Lot 3.—Raw, naturally ripened, acidity 0.6%.
Lot 4.—Raw, naturally ripened, acidity 0.6%, neutralised to 0.25%.
Lot 5.—Pasteurised, unripened.
Lot 6.—Pasteurised, starter ripened, acidity 0.4%.
Lot 7.—Pasteurised, starter ripened, acidity 0.6%.
Lot 8.—Pasteurised, starter ripened, acidity 0.6%, neutralised to 0.25%.
Lot 9.—Pasteurised after natural ripening to 0.4% acidity.
Lot 10.—Pasteurised after natural ripening to 0.6% acidity.

Unfortunately, the workers did not make up another lot in which the acidity was obtained by the addition of pure lactic acid.

All obvious precautions were taken in the butter making such as working in an earthenware hand churn and avoiding contact with metal surfaces.

The butter made from each of the ten lots of cream was divided into seven parts which were treated as follows:—

Part 1.—Unsalted.
Part 2.—Medium salted, 1.5% salt.
Part 3.—Highly salted, 3.0% salt.
Part 4.—Highly salted, 3.0% salt, plus 0.1% ferric oxide.
Part 5.—Highly salted, 3.0% salt, plus 0.1% iron lactate.
Part 6.—Highly salted, 3.0% salt, plus 0.1% tin lactate.
Part 7.—Highly salted, 3.0% salt and overworked.

Each of the seven parts prepared from each of the ten lots of cream was divided into two parts; one of these was stored at -10°F., the other was stored at 35-40°F. The samples were scored by three judges at intervals of about a month and the different flavours carefully noted. For results see Table A.

From the results obtained Sommer and Smit drew the following conclusions:—

"1. Fishiness appeared earlier and more often in the samples stored at the higher temperature.

2. True fishiness was found practically only in the unpasteurised samples (lots 1, 2, 3 and 4).

3. Pasteurisation after ripening (lots 9 and 10) seemed to be more effective in preventing fishiness than pasteurisation before ripening (lots 5, 6, 7 and 8). Lots 6 and 7, pasteurised and then ripened, showed fishiness in the samples containing 3.0% salt and iron lactate, while the corresponding lots, lots 9 and 10, pasteurised after ripening, showed no signs of fishiness.

4. The high acid samples, lots 2 and 3 especially, developed fishiness most rapidly.

5. None of the unsalted and low salted samples developed fishiness.

6. Only one of the samples where acidity and salt alone were active developed a slightly fishy odour.

7. The presence of iron oxide and iron lactate combined with high acid and salt caused the most distinct and greatest number of fishy samples. The iron lactate was more active than iron oxide.

8. Tin lactate did not cause fishiness.

9. Overworking showed a slight tendency to aid the development of fishiness.

10. Neutralisation to a low acidity before churning was effective in reducing fishiness. Lots 4 and 8, neutralised to 0.25% acid, showed less fishiness than the corresponding unneutralised samples, lots 3 and 7.

"Thus the results of these experiments clearly show that high acid, high salt and oxidation produced by overworking, but more especially by the aid of catalysers, are the important factors in the development of fishiness. The results also show that pasteurisation and neutralisation are effective means of checking fishiness."

Let us review the experiments mentioned in Tables A and B. In the first place it seems quite obvious that the presence of salt up to 3 per cent., with or without acid up to 0.6 per cent., in the absence of other factors, does not result in breakdown of the lecithin to give trimethylamine. In the case of the samples made from cream lot 3, enzymic decomposition was possible, and further, a large number of samples containing both high acid and high salt contents did not develop fishiness.

TABLE A.

FLAVOURS DEVELOPED IN THE EXPERIMENTAL BUTTER AT 35 TO 40° F.

Lot number.	Months storage.	Treatment of the Butter.						
		Unsalted.	1·5% salt.	3·0% salt.	3·0% salt plus 0·1% ferric oxide.	3·0% salt plus 0·1% iron lactate.	3·0% salt plus 0·1% tin lactate.	3·0% salt plus overworking.
1	4	....	Slightly oily	Slightly oily	Metallic	Oily	Slightly oily	Slightly oily
	6	....	Slightly oily	Slightly oily	Metallic and oily	Slightly fishy	Slightly oily	Slightly oily
	8	....	Slightly oily	Oily	Slightly fishy	Fishy	Oily	Oily
2	4	....	Slightly oily	Oily	Slightly fishy	Fishy	....	Oily
	6	....	Slightly oily	Oily	Fishy	Very fishy	....	Slightly fishy
	8	....	Slightly oily	Very oily	Fishy	Very fishy	....	Oily and fishy
3	4	....	....	Very oily	Slightly fishy	Very fishy	....	Very oily
	6	....	....	Very oily	Fishy	Very fishy	....	Fishy
	8	....	....	Slightly fishy	Fishy	Very fishy	....	Oily and fishy
4	4	....	....	Slightly oily	Oily	Very oily	....	Oily
	6	....	....	Slightly oily	Oily	Fishy	....	Oily
	8	....	....	Oily	Tallowy	Fishy and tallowy	....	Oily
5	4	....	Oily	Oily	Oily	Oily	....	Oily
	6	....	Oily	Oily	Oily	Very oily	....	Oily
	8	....	Oily	Oily	Tallowy	Fishy	Oily	Very oily
6	4	....	....	....	Oily	Metallic and oily	....	Oily
	6	....	....	....	Oily	Slightly fishy	....	Oily
	8	....	....	....	Tallowy	Tallowy	....	Very oily
7	4	....	....	....	Oily	Oily	....	Oily
	6	....	....	....	Oily	Slightly fishy	....	Oily
	8	....	....	....	Very oily	Tallowy	....	Very oily
8	4	....	....	....	Oily	Metallic and oily	....	Slightly oily
	6	....	....	....	Oily	Oily	....	Slightly oily
	8	....	....	....	Oily and tallowy	Tallowy	....	Tallowy
9	4	....	....	Slightly oily	Metallic	Very metallic	....	Slightly oily
	6	....	....	Slightly oily	Oily	Metallic and oily	....	Slightly oily
	8	....	....	Oily	Oily	Tallowy	....	Oily
10	4	....	....	....	Oily	Metallic and oily	....	Oily
	6	....	....	....	Oily	Oily	....	Oily
	8	....	....	Oily	Oily and tallowy	Tallowy	...	Very oily

TABLE B.

FLAVOURS DEVELOPED IN THE EXPERIMENTAL BUTTER AT 10° F.

Lot number.	Months storage.	Treatment of the Butter.						
		Unsalted.	1·5% salt.	3·0% salt.	3·0% salt plus 0·1% ferric oxide.	3·0% salt plus 0·1% iron lactate.	3·0% salt plus 0·1% tin lactate.	3·0% salt and overworking.
1	4	....	....	....	Metallic and oily	Metallic and oily	....	....
	6	....	....	Oily	Very oily	Oily and fishy	....	Oily
	8	....	....	Oily	Fishy and tallowy	Fishy and tallowy	....	Oily
2	4	....	....	....	Oily	Very oily	....	....
	6	....	Slightly oily	Oily	Slightly fishy	Fishy	....	Oily
	8	....	Slightly oily	Very oily	Fishy and tallowy	Fishy and tallowy	....	Very oily
3	4	....	....	Oily	Metallic and oily	Very oily	Oily	....
	6	....	Oily	Oily	Slightly fishy	Fishy	Oily	Oily
	8	....	Oily	Oily and tallowy	Fishy and tallowy	Fishy and tallowy	Oily	Very oily
4	4	....	....	....	Metallic and oily	Metallic and oily		
	6	....	....	Oily	Metallic and oily	Metallic and oily	....	Oily
	8	....	....	Oily	Oily and tallowy	Tallowy	....	Oily
5	4	....	....	....	Metallic	Metallic and oily		
	6	....	....	Slightly oily	Slightly oily	Oily	....	Oily
	8	....	....	Oily	Tallowy	Tallowy	....	Oily
6	4	....	....	Oily	Metallic and oily	Oily	....	....
	6	....	....	Oily	Very oily	Slightly fishy	....	Oily
	8	....	....	Very oily	Tallowy	Fishy and tallowy	....	Very oily
7	4	....	....	Oily	Metallic and oily	Oily		....
	6	....	....	Oily	Very oily	Slightly fishy	Slightly oily	Oily
	8	....	....	Very oily	Tallowy	Fishy and tallowy	Oily	Oily
8	4	....	....	Oily	Metallic	Oily	Slightly oily	....
	6	....	....	Oily	Oily	Oily	Slightly oily	Slightly oily
	8	....	....	Oily	Tallowy	Tallowy	Oily	Oily
9	4	....	....	Oily	Oily	Oily	....	....
	6	....	....	Oily	Very oily	Very oily	....	Oily
	8	....	....	Oily	Tallowy	Tallowy	....	Very oily
10	4	....	....	Oily	Oily	Oily	....	....
	6	....	....	Oily	Very oily	Very oily	....	Oily
	8	....	....	Very oily	Tallowy	Tallowy	....	Very oily

The experiments do not indicate whether the presence of salt is necessary, in addition to such factors as enzymes and metallic contamination, to produce the fishiness. However, O'Callaghan stated that much Australian unsalted butter was criticised as fishy when it arrived in London (73). Washburn and Dahlberg noted in their experiments that fishiness could develop in unsalted butter (5). The experiments of Supplee also indicate that fishiness develops in unsalted butter (6).

The experiments of Sommer and Smit, noted above, indicate that high acidity is not necessary for the development of fishiness (lots 1, 4 and 5). For two of these lots the acidity is not given: in one case the cream was sweet, however, and in the other case the butter was made from cream neutralised to 0.25 per cent. acidity. Included in the paper by Supplee is data for a number of samples prepared from cream having acidity as low as 0.16 per cent. which went fishy during storage (6).

However, notwithstanding the fact that salt and acidity are unnecessary for the development of fishiness in butter during storage, there is a general consensus of opinion that the defect is more often noted in the presence of such factors. This is shown in the review of the literature by Sommer and Smit (1).

In the first place, as previously mentioned, the presence of acid and salt will make more evident a defect which otherwise might have passed unnoticed.

However, experiments indicate that both acid and salt favour the development of fishness. The following data from the work of Washburn and Dahlberg illustrate the effect of salt (5) :—

Churn No.	Salt.	Judge's Comments on the Butter.			
		Initial.	113th Day.	284th Day.	304th Day.
	%				
3	0	Good	Trifle mouldy, cheesy	Slightly unclean, metallic	Weak body, bitter, curdy.
	1·72	Will not go fishy	Metallic	Slightly oily, slightly fishy	Fishy.
2	0	Good	Trifle rancid	Slightly fishy, slightly unclean	Fishy, overworked, body poor.
	2·07	Tendency to fishy	Metallic	Slightly oily, slightly fishy	Fishy.
6	0	....	Metallic	Slightly oily, slightly fishy	Weak body, fishy.
	2·41	....	Fishy	Fishy, coarse	Fishy, overworked, body poor.
1	0	Dry	Rancid, metallic	Metallic, cheesy, slightly unclean	Fishy, overworked, body poor.
	2·51	Tendency to fishy	Fishy	Fishy, slightly unclean	Fishy, bad.
4	0	Good	Metallic, old flavour	Fishy	Weak body, overworked, slightly fishy.
	3·27	Good	Metallic	Fishy	Fishy.
5	0	Extra fine aroma	Slightly metallic	Good aroma, slightly oily	Flat storage flavour, weak body.
	3·79	....	Coarse, not fishy	Coarse, unclean	Fishy.

Butter samples prepared from cream ripened to an acidity of 0.58 per cent. were stored for 284 days at —15°F. and for a further 20 days at 58°-60°F. Salted and unsalted samples were prepared from each churning. Unfortunately, salt was not added to the unsalted samples at the time of tasting and possibly, had this been done, fishiness would have been detected in both members of a pair where it was only noted in one member (the salted sample) in the results as reported. Sommer and Smit said:—"However, besides this intensifying effect of the salt," on the flavour, "it must also be involved in the actual production of the flavour, because fishiness is not produced by simply incorporating salt into an unsalted sample of butter, the corresponding salted sample of which has become fishy in storage." No relevant data regarding this statement were presented.

In view of the effect of salt in controlling deterioration when the material is held at room temperature, which will be mentioned later, it is important to note that salt, in itself, has not been shown to cause deterioration in cold storage.

The following statement of Rogers *et alia* regarding the effect of acidity is characteristic (74) :—"In a tabulation of the examination of 259 samples of experimental butter from cream of known acidity, of 137 samples from cream having an acidity below 0.3 per cent. only 2, or 1.5 per cent., were marked 'fishy,' while of 122 samples having an acidity of 0.3 per cent. or over, 60, or 49.2 per cent., were fishy."

Rogers and Gray presented the following data showing the effect of acidity in causing deterioration (75) :—

THE INFLUENCE OF DIFFERENT ACIDS ON THE FLAVOUR OF BUTTER.

Lot.	Acid added.	Acidity of Cream. %	Score after 15 days.
1a	None ...	0·144	88—Trifle unclean and very greasy.
1b	Lactic ...	0·216	88—Trifle unclean and very greasy.
1c	Lactic ...	0·432	86—Fishy and greasy.
2a	None ...	0·126	90—Trifle oily, body weak and greasy.
2b	Acetic ...	0·216	87—Very greasy, rancid and fishy odour.
2c	Acetic ...	0·350	84—Very fishy and greasy.
3a	None ...	0·126	90—Clean but greasy.
3b	Hydrochloric	0·225	90—Trifle unclean and oily.
3c	Hydrochloric	0·450	84—Very fishy, greasy.

In these experiments the samples were not all brought to the same acidity at the time of examination, and, in view of the effect of acidity on the flavour of butter, are therefore open to criticism.

In the study of butter deterioration at least three factors must be given consideration. These are:

(1) The growth of bacteria with the liberation of bacterial exocellular enzymes.

(2) Deterioration produced by the bacterial enzymes, and

(3) Deterioration due to purely chemical factors.

In general, at low storage temperatures where the growth of micro-organisms is mainly inhibited and the deterioration is probably mainly due to chemical factors (as appears to be the case with the development of fishiness), one would expect the greatest deterioration in the most acid material—due to such effects as increased activity of metallic impurities.

Wiley reported the following data showing the effect of acid in causing deterioration of unsalted butter (76).

	Method of Manufacture.	Loss on Storage (points).		
		16 Weeks at 40° F.	18 Weeks at 14° F.	18 Weeks at 0° F.
1	Sweet cream	2·6	1·1	1·1
2	Sweet cream neutralised to pH 7·3	2·55	0·75	0·75
3	Ripened to pH 6	1·7	2·3	2·0
4	Lactic acid added to pH 6	3·7	1·5	1·6
5	Ripened to pH 5	3·6	2·0	2·3
6	Lactic acid added to pH 5	5·3	0·8	0·55
7	Ripened to pH 6 and neutralised	2·3	1·1	1·1
8	Ripened to pH 5 and neutralised	1·7	0·5	0·4

In the first place, the results of Wiley are not comparable with those of Rogers and Gray because his material was unsalted. Further, Rogers and Gray noted the effect of acidity on the development of the specific defect called fishiness,

but the type of deterioration in Wiley's samples was different, the samples turning stale, cheesy, rancid or fruity. Wiley's results are mentioned because they show the effect of different factors.

Let us consider experiments Nos. 1, 3 and 4. When stored at 40° F. at which temperature the growth of bacteria is likely to be marked, the products of the lactic fermentation have apparently repressed microbial growth and the loss of grade was less than in the case of the unripened sample. Pure lactic acid does not appear to be the main bacterial product responsible for checking the growth of the organisms and when added to cream accelerated chemical decomposition. At the lower temperatures of storage the growth of organisms will be checked and chemical deterioration will be the notable effect. Thus it will be seen that the addition of lactic acid slightly increased the deterioration. In the case of the ripened sample the deterioration was still more marked presumably because of the effect of the acid and of bacterial enzymes produced during the ripening process.

To return to the subject of lecithin decomposition, Sommer and Smit made experiments to determine the effect of acid and salt in causing breakdown of an emulsion of this substance (1). Mercuric chloride was used to prevent bacterial decomposition The samples were kept in an incubator adjusted to 28°C. for three weeks. The following data resulted:—

THE CHEMICAL DECOMPOSITION OF LECITHIN INTO TRIMETHYLAMINE.

Treatment of Sample.	0·1% Lecithin plus:				
	Nothing.	0·1% Ferrous Lactate.	H_2O_2 1 cc. to 14 cc.	Oxygen.	0·1% Ferrous Lactate plus O_2.
	Per cent. Trimethylamine of total possible.				
No salt, no acid	1·89	1·46	2·49	2·16	2·50
2% salt, no acid	2·85	1·66	5·77	2·85	4·65
4% salt, no acid	2·85	2·50	5·77	2·85	4·99
No salt, 0·25% lactic acid	4·22	3·32	8·79	6·55	6·60
No salt, 0·50% lactic acid	4·48	4·32	10·34	10·52	7·93
2% salt, 0·25% lactic acid	5·60	4·98	11·29	14·65	8·43
4% salt, 0·25% lactic acid	5·60	5·77	11·20	14·82	8·13
2% salt, 0·50% lactic acid	5·77	7·41	13·78	17·23	8·87
4% salt, 0·50% lactic acid	6·29	7·41	14·04	17·75	9·13

"Note: The amount of lecithin, ferrous lactate, salt and acid are expressed on the basis of butter (16% moisture) corresponding to these emulsions, *i.e.*, the actual concentration of these substances in the emulsions is 6¼ times as great as stated in the table."

"The results given show that lecithin will undergo decomposition and yield trimethylamine under conditions that exclude bacterial action. This decomposition takes place most readily under conditions that combine salt, high acid and oxidation. These results correlate very nicely with the conditions known to favour the development of fishiness, and thus lend support to the theory that the fishy flavour results from the chemical decomposition of lecithin yielding trimethylamine."

In explaining the effect of salt and acid in accelerating the decomposition of lecithin, Sommer and Smit note:—

1. Salt solutions dissolve lecithin;
2. Salt lowers the freezing point of brine; and
3. The addition of salt to butter necessitates additional working of the butter, a factor favouring oxidation.

Acid conditions favour the decomposition of lecithin because:

1. Acids accelerate hydrolysis,
2. Acidity aids oxidation; and
3. Acids in the cream cause the absorption of metals during the manufacturing process.

The writer would point out that probably the main effect of the acid brine is to activate the metals because of the high ionic activity; further, concerning butter made from high acid cream, it is probably the action of microbial pro-oxidative enzymes which causes the defect, an explanation which agrees with the findings that pasteurisation of such creams generally stops the development of the defect.

Attempts to produce a fishy flavour in butter by bacterial inoculation have led to conflicting results.

Reakes, Cuddie and Reid found that plugs of fishy butter inserted into clean butter did not cause fishiness to be developed in the clean butter (77).

Rogers in surveys of creameries where outbreaks of fishy butter had been noted found no unusual species of bacteria in the products and was unable to produce fishiness in cream by inoculating it with bacteria isolated at such creameries (75).

Supplee was able to produce fishy butter from cream that had been ripened 24 hours after inoculation with B. *ichthyosmius* or a certain unnamed organism (6).

Cusick also was able to produce fishy taint butter from cream ripened after addition of B. *ichthyosmius* (79).

Sommer and Smit studied the two organisms used by Supplee (1). They found that the two organisms could produce trimethylamine from lecithin given suitable conditions, but the organisms failed to grow in conditions that are favourable for the development of fishiness,*i.e.*, salt and acid conditions. They consider that the investigators who claim to have produced fishiness in butter by means of bacteria either did not exclude the factors that lead to chemical decomposition of lecithin, or they produced the defect in quite abnormal conditions.

The writer, however, cannot agree with the opinions of Sommer and Smit. As explained above, salt and acidity in the absence of other factors do not cause fishiness. The organisms studied by Supplee and Cusick may, during their growth in the cream, have produced enzymes capable of causing the necessary type of lecithin decomposition. As the cream was not heat treated, such enzymes would remain active in the butter even though development of the organisms was inhibited.

THE MICROBIOLOGICAL EXAMINATION OF BUTTER.

The same two methods which are used for the determination of the numbers of bacteria in milk samples may also be used for determining the numbers of bacteria in butter samples. These are the "direct count" method and the "plate count" method.

The "direct count" method was adapted to the examination of butter samples by Hammer & Nelson (87). Fay has also described a suitable technique (88).

The "direct count" method has but limited use in the examination of butter because many of the organisms to be seen are dead. In the case of pasteurised butter prepared from sour cream or cream which has been ripened with starter, this is particularly so.

Most of the plate counts of bacteria present in butter samples recorded in the literature are probably far too low. This is especially to be expected when the counts were made upon beef-extract agar, a medium far different in com-

position from butter, the medium in which the organisms have been growing. Counts made on whey-agar media can be expected to be more reliable. However, even with these media, care would be necessary in selecting the milk for its preparation, as milk drawn from animals suffering from mastitis can be expected to contain inhibitory chemical substances. Probably media of the type recently suggested for making counts of the organisms in milk will eventually be generally used for butter work (89, 90).

The following portion of a summary, abstracted from the report by Wilson *et alia,* will serve to show the limitations of the "plate count" (89):

"Ostensibly it measures the numbers of bacteria in milk, but in fact it does not. On account of the difference between various species of bacteria in their nutritional, respiratory, and temperature requirements, on account of the fact that many organisms may be dead, and, most important of all, on account of the gross irregularity in the distribution and clumping of the organisms in the milk, the plate count merely registers the number of bacterial units capable of multiplying under the particular conditions selected. Since the average number of bacteria per clump is variable from one milk to another, and from time to time in the same milk, and since these clumps may disintegrate to a quite uncontrollable extent during the process of dilution, it follows that the figures yielded by the plate count are arbitrary, not strictly comparable from milk to milk, merely approximate, and have no real significance.

"The technique is complex, is difficult to standardise, and requires highly-skilled workers. Even under favourable conditions, with the method standardised as far as possible, the experimental error is very large, and on any one count an allowance of ± 90% may have to be made. Even this margin of error will not include all results . . . . . "

The above criticism, although written in connection with the bacteriological grading of milk, is applicable almost word for word to the examination of butter samples.

However, notwithstanding the factors noted in the above criticism, the plate count shows a surprisingly high correlation coefficient when compared with the "individual direct count" (at the moment milk is again being considered) and, in the present state of our knowledge, the individual direct count must be accepted as giving the closest estimation of the total numbers of organisms in milk samples. To quote from the "Standard Methods of Milk Analysis" (91):— "As it is only in this way that counts of bacteria themselves can be made, it must be recognised that accurately made microscopic counts of individual bacteria give the truest picture of the actual number of bacteria in raw milk that can be obtained with any technique."

Robertson & Frayer report the following data showing the relationship between the "agar plate count" and the "individual microscopic count" (104).

Temp. of Expt.	No. of Samples.	No. of obs.	Co-eff. of Correlation.	Standard Deviation.
80° F.	17	139	+ ·90	± log. 1·42
70° F.	17	228	+ ·93	± log. 1·37
60° F.	17	353	+ ·94	± log. 1·37
50° F.	10	302	+ ·94	± log. 1·30

It must be admitted that, so far as milk count work is concerned, when "plate counts" are correlated with "individual direct counts," the standard deviation is very high; the mean standard deviation in the above table is ± log 1.37.

To consider the application of the "plate count" to butter deterioration studies, the standard deviation in any series of experiments can be expected to be less than that above. The reasons are as follows:—

(1) The "direct count" takes into consideration all organisms, alive or dead, and, in the case of butter deterioration, we are concerned only with the living organisms.

(2) Instead of having to satisfy the nutritional requirements of all the organisms present, it is only necessary to supply the requirements of organisms capable of developing in butter.

We can conclude that, when a fair number of samples of butter are examined by the "plate count" method a high degree of correlation may be expected between the mean counts obtained and the number of organisms capable of developing in the butter. Individual counts, however, may be far from correct.

For the purpose of shortening the time of incubation, "microscopic colony counts" have been suggested. In connection with butter work, Johns has described such a method for the determination of the numbers of yeasts and moulds in butter (96). Recently, Moir and Russell have described such methods for both yeast and mould counts and for bacterial counts (97). The above criticism of the "plate count" method is generally applicable to the "microscopic colony count" method.

(*To be continued.*)

Agricultural Problems.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

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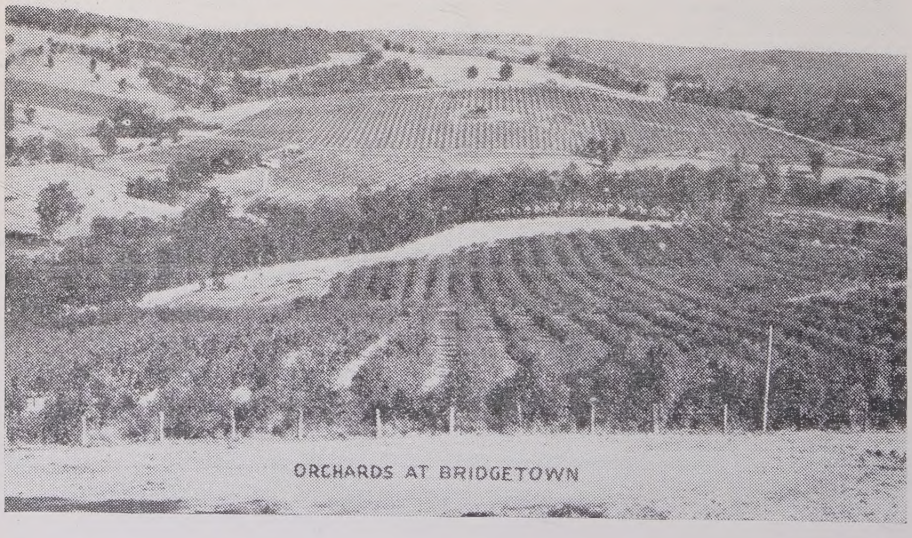

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